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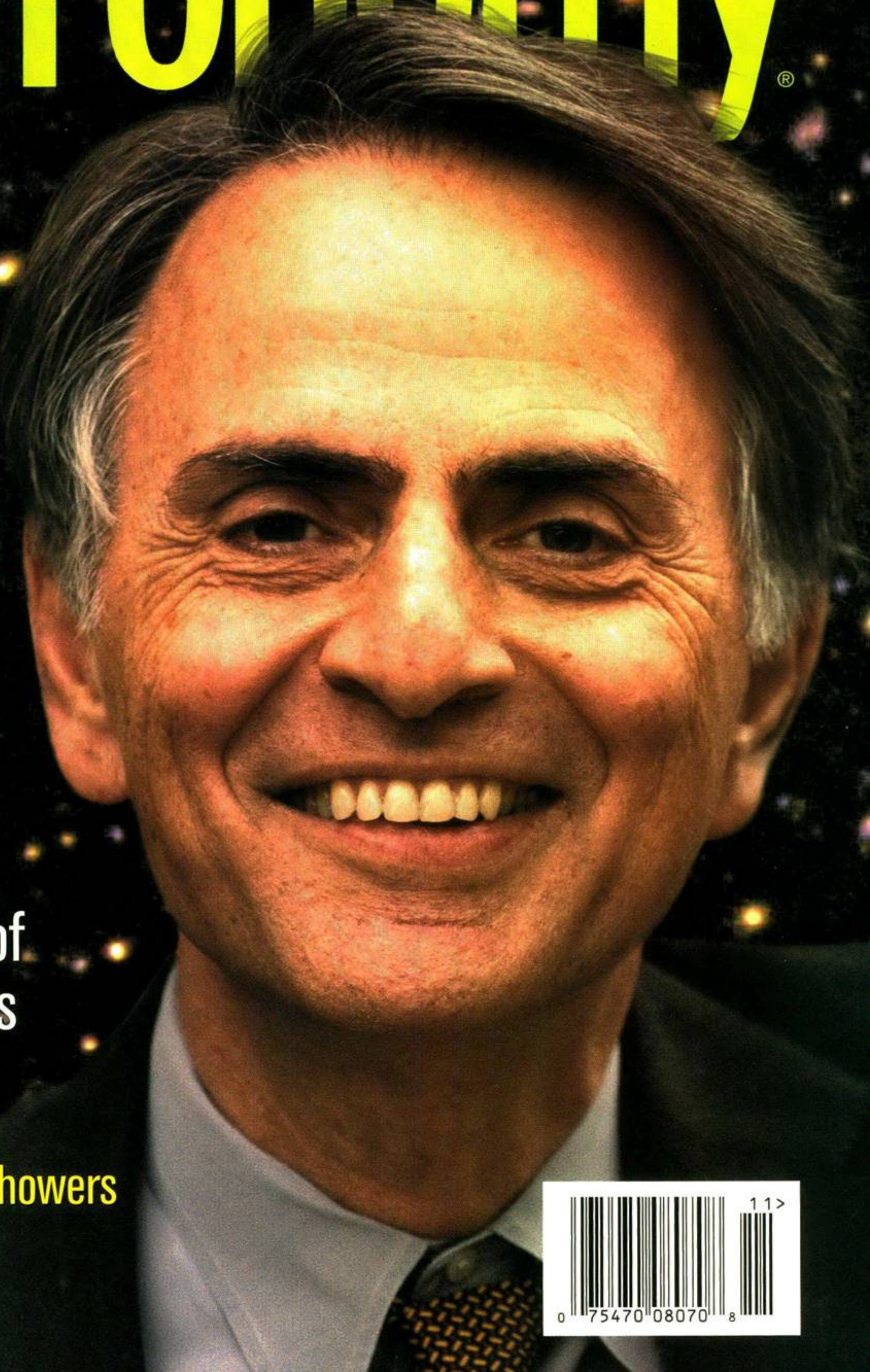

The Genesis of Carl Sagan

Scariest Menaces in Space

A New Gallery of Oddball Galaxies

PLUS:
Viewing 2 Meteor Showers

Now two ETX apertures!
ETX-90EC — $595
ETX-125EC — $895

Now you can buy the revolutionary Meade ETX® — the largest selling modern telescope in the world — in either of two apertures, 3.5" or 5". Both models include the very latest in microprocessor-controlled capability.

New Fork Mount Designs with Standard-Equipment Dual-Axis Drive Systems: Each with high-torque DC motors on both telescope axes, permitting electronic operation from the standard-equipment plug-in hand controller.

Pushbutton Electronic Hand Controller: Use at any of four dual-axis speeds: 8x for image centering at high power; 32x for image centering at lower power or for pushbutton object-tracking in the altazimuth mode; 0.75°/sec for image centering in the viewfinder or for terrestrial tracking; 5°/sec for fast slewing across the sky.

Cordless Operation: The dual-axis drive system operates for more than 40 hours from eight (user-supplied) AA batteries which store neatly inside the drive base.

Optional Autostar™ Capability: Plug in the optional Meade Autostar computer controller *(see facing page)* for LX200-type operation, including automatic GO TO capability to more than 14,000 celestial objects.

Plus the features that created the ETX revolution:

Maksutov-Cassegrain Optical Systems: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that ETX telescopes often outperform other telescopes of larger apertures.

Flip-Mirror System: Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter.

SPECIFICATIONS: ETX-90EC and ETX-125EC Astro Telescopes — Each includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8 *or* D = 127mm, F = 1900mm, f/15) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; fork mount with electric slow-motion controls, setting circles and locks on both axes; electronic control panel; 4-speed (8x, 32x, 0.75°/sec, 5°/sec) dual-axis motor drive system with hand controller; sidereal-rate tracking in equatorial mode with optional table tripod or deluxe field tripod; internal battery compartment accepting eight (user-supplied) AA-size batteries; 8 x 21mm erect-image (ETX-90EC) *or* 8 x 25mm right-angle (ETX-125EC) viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); instructions. **ETX-90EC — $595** (+ $20 packing & shipping in the 48 states); **ETX-125EC — $895** (+ $30 P & S).

MEADE
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NEW!
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COMPUTER CONTROL
COMPUTER CONTROL
FOCUS
SPEED
MODE
MEADE
MEADE

Meade ETX-90EC: $595 and ETX-125EC: $895. Each complete as shown, with electronic hand controller; plus packing and shipping.

OPTIONAL SYSTEMS*

#497 Autostar Computer Controller (90, 125)	$149
#880 Equatorial Table Tripod (90)	29.95
#881 Equatorial Table Tripod (125)	59.95
#883 Deluxe Field Tripod (90, 125)	199.95
#825 8 x 25mm Right-Angle Viewfinder (90)	49.95
#774 Hard Carry Case (90)	99.95
#775 Hard Carry Case (125)	149.95
#932 45° Erecting Prism (90, 125)	49.95
#64 Photo Adapter (90, 125)	34.95
Electric Focuser #1244 (90) *or* #1247 (125)	119.95

**see the Meade accessory ad in this issue.*

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FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

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EFSTONSCIENCE, Toronto, Ontario, Canada
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KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

Add the Meade Autostar™ computer to your ETX-90EC or ETX-125EC for automatic GO TO object location ...only *$149!*

ETX AUTOSTAR
RA = 08:04.6
Dec = +36°38
MEADE
ENTER
MODE
GO TO
1
2
3
4
5
6
7
8
9
0
?

Plug the #497 Autostar Computer Controller into your ETX-90EC or ETX-125EC and you're ready for an incredible array of LX200-type capabilities:

Automatic dual-axis GO TO function at 5°/sec to any of more than 14,000 database objects, including deep-space objects (galaxies, diffuse nebulae, planetary nebulae, star clusters — the best objects from the IC, NGC and Caldwell catalogs, as well as all 110 Messier objects); 900 stars (double stars, variable stars, SAO stars); the 8 major planets from Mercury to Pluto; 26 of the brightest asteroids; 15 periodic comets; 50 earth-orbiting satellites; plus user-defined objects and the centroids of all 88 constellations. Select any of these objects, press ***GO TO*** and the telescope automatically slews to the object, placing it in the telescopic field.

Automatic GO TO function to *any* object of known R.A. and Dec.

Digital readouts of telescope position (continuously in R.A. and Dec.), menu options, glossary, and utility functions.

Precise sidereal-rate tracking in either altazimuth or equatorial modes. For altazimuth tracking, set the telescope on its drive base and perform a quick, easy alignment.

9-Speed Dual-Axis Operation: Pushbutton operation of the telescope on both axes, simultaneously, at any speed from 2x sidereal to 5°/sec.

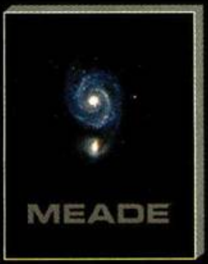
RS-232 Serial Port: For operation of the telescope through a personal computer, using Meade Epoch 2000® sky software or other sky software using the LX200 protocol.

Plus: over 20 other menu options, including guided tours, major event menus, user-defined terrestrial objects, and much more.

The Meade #497 Autostar Computer Controller *(shown actual size)* plugs in to the control panel of the Meade ETX-90EC or ETX-125EC telescope and permits LX200-type automatic object location from a 14,000-object database, a database that includes virtually every astronomical object visible with the ETX-90EC or ETX-125EC — **$149.**

MEADE
COMPUTER CONTROL

(right) **Meade ETX-90EC,** shown with optional #497 Autostar Computer Controller plugged into the telescope's control panel.



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Patents pending on ETX-90EC, ETX-125EC, and Autostar.

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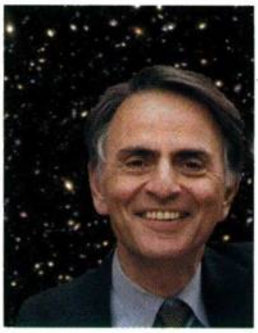

COVER PHOTO: Michael J. Okoniewski/Background photo by ESO

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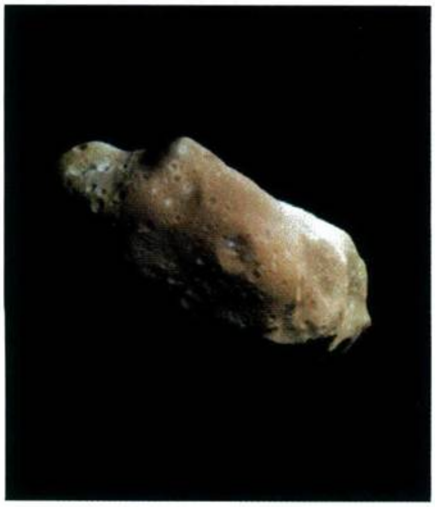

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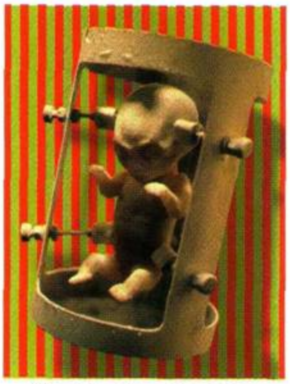

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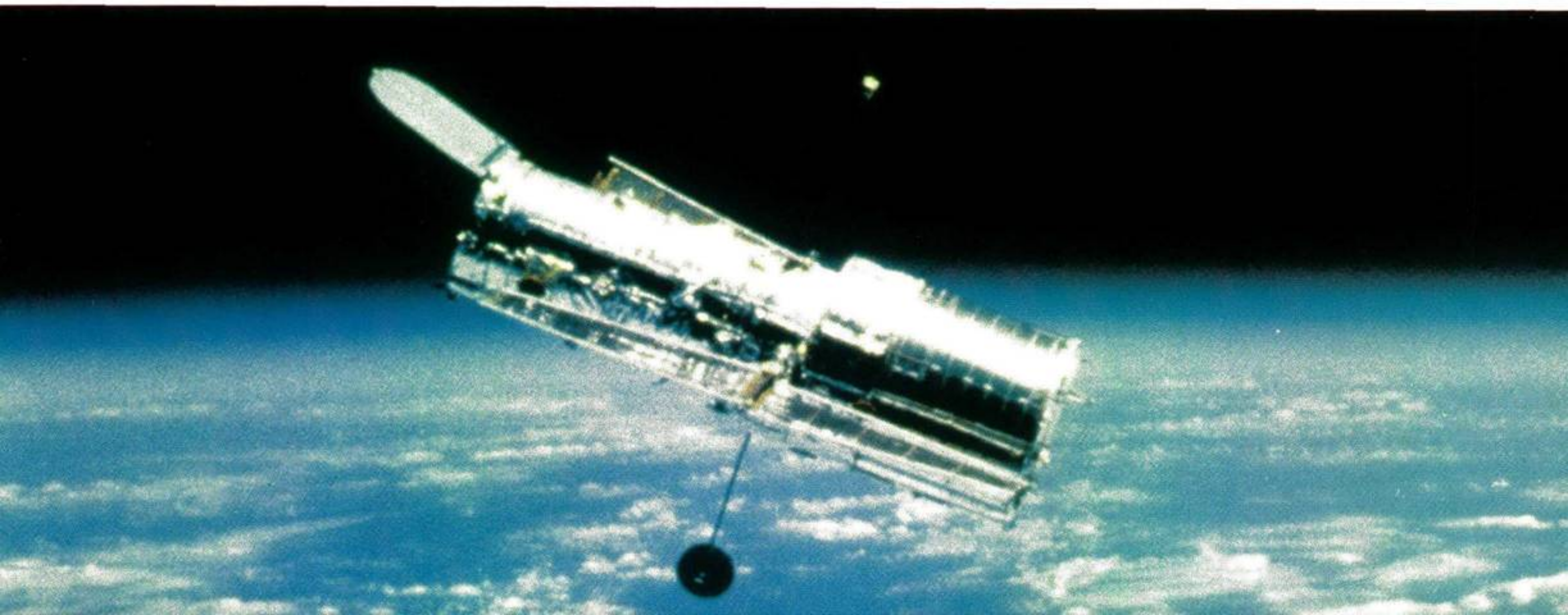


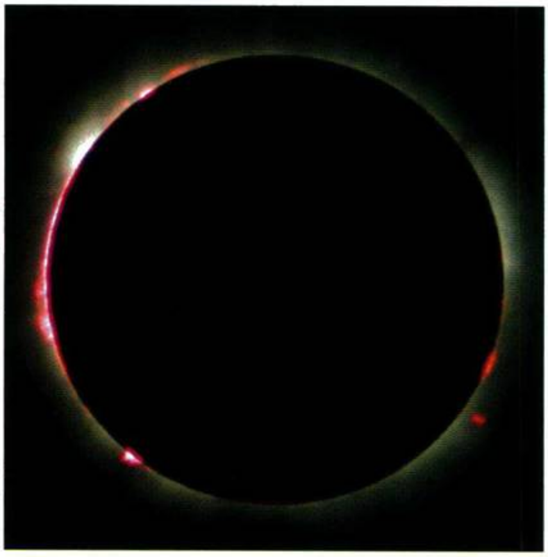
BEHIND THE SCENES

BY BONNIE BILYEU GORDON

The Dangerous Sky

Every one of us wondered during the total eclipse in August how preliterate humans fared in the face of totality. Eclipses drummed up fear and confusion even among the shore birds flying over the Black Sea. They began nesting for the night in our ship's lines. In the past, humans must have also run for cover, predicting the worst from this sudden short night.

Thousands of travelers turned what once was a frightening experience into a joyous pilgrimage throughout Europe and Asia this summer. Tears of strong emotion fell at totality, despite the fact that we all knew what to expect. And after the tears and celebration, even repeat eclipse watchers were left a little stunned. As regular *Astronomy* writer Bob Berman says, "The last eclipse you've seen is always the best one." (See eclipse photos on page 88.)


Mike Stegina/Jim Eckert: Black Sea eclipse of August 11, 1999.

While eclipses are no longer a cause for alarm among most people today, there are a few threats the sky still holds. Some universal dangers are enumerated in Robert Zimmerman's story "When Disaster Strikes" on page 46. He includes everything from comet collisions to gamma-ray bursts, calculating our risk. He even includes alien invasion, but he leaves one out that's my personal favorite. It's a danger grander and more difficult to combat than asteroids or supernovae.

If cosmologist Andre Linde is correct and our universe is a quickly growing patch of a much larger multiverse, our piece could collapse in an instant. The multiverse theory and the potential it holds for our very quick annihilation may have given Mr. Zimmerman pause. He probably thought this outcome too theoretical, but I say if you have to fret, fret over something big.

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8" LX10

8" LX10 DELUXE

The optical performance of a Meade 8" LX200 Schmidt-Cassegrain...for only *$995!*

8" LX10: For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *Standard-equipment includes:*

Super-Multi-Coated Optical System: The *exact same* multi-coated 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. **Series 4000 SP26mm eyepiece:** Complements the exquisite imaging of Meade 8" SC optics. **Equatorial Fork Mounting:** The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. **Cordless, DC-Powered Electronic Motor Drive:** With electronically-regulated DC servo motor for automatic *sidereal-rate* tracking; powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours. **Worm-Gear System:** The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging. **Hand Controller:** Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); SP26mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions. **$995.** (+ $65 packing & shipping in the 48 states)

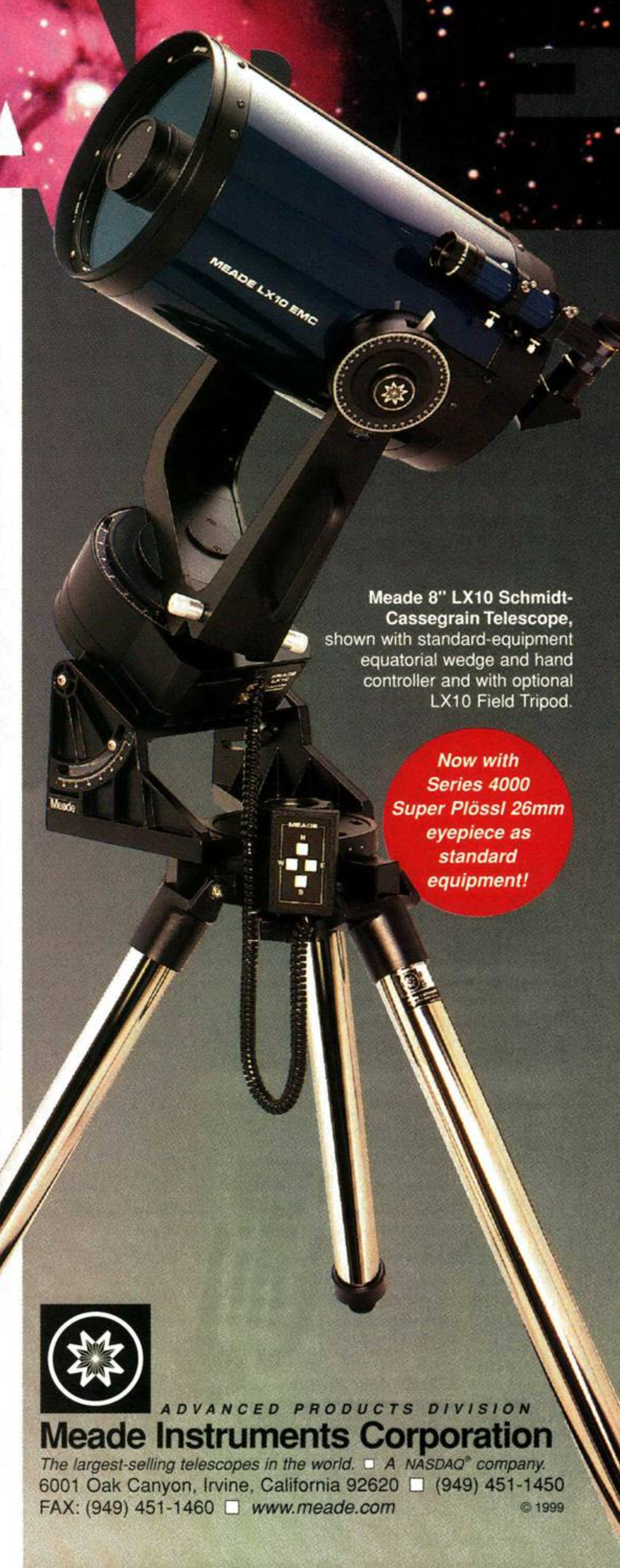
8" LX10 Deluxe: At only $1149 the 8" LX10 Deluxe includes (a) the large-aperture Meade #544 8 x 50mm viewfinder (in place of the standard 6 x 30mm finder); (b) the LX10 Electric Declination Motor System, permitting dual-axis guiding corrections at 2x speed; and (c) Meade Epoch 2000 Jr. Sky Software with 10,000-object database — all at substantially lower cost than if the respective accessories were purchased separately.

SPECIFICATIONS: 8" Model LX10 Deluxe — Identical in all specifications to 8" Model LX10, above, but with Electric Declination Motor System provided as standard equipment, permitting dual-axis corrections at 2x speed; Meade #544 8 x 50mm achromatic viewfinder in place of 6 x 30mm viewfinder; and Meade Epoch 2000 Jr. Sky Software with 10,000-object database.

$1149. (+ $65 packing & shipping in the 48 states)

Field Tripod for LX10 or LX10 Deluxe	195.
Electric Declination Motor System for LX10	95.
#2014 Magellan I Telescope Computer System for LX10 or LX10 Deluxe, with 12,218-object database	375.

The 120-page Meade General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers.
Prices shown are suggested U.S. mail-order prices.



Meade 8" LX10 Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

Now with Series 4000 Super Plössl 26mm eyepiece as standard equipment!

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Advanced technology at the most affordable prices *ever.*

■ **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel.

■ **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A.

■ **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*.

■ **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ **Massive LX200-type Fork Mounts:** Manufactured of the same aluminum castings as Meade LX200 models. Massive, rigid mounts that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications.

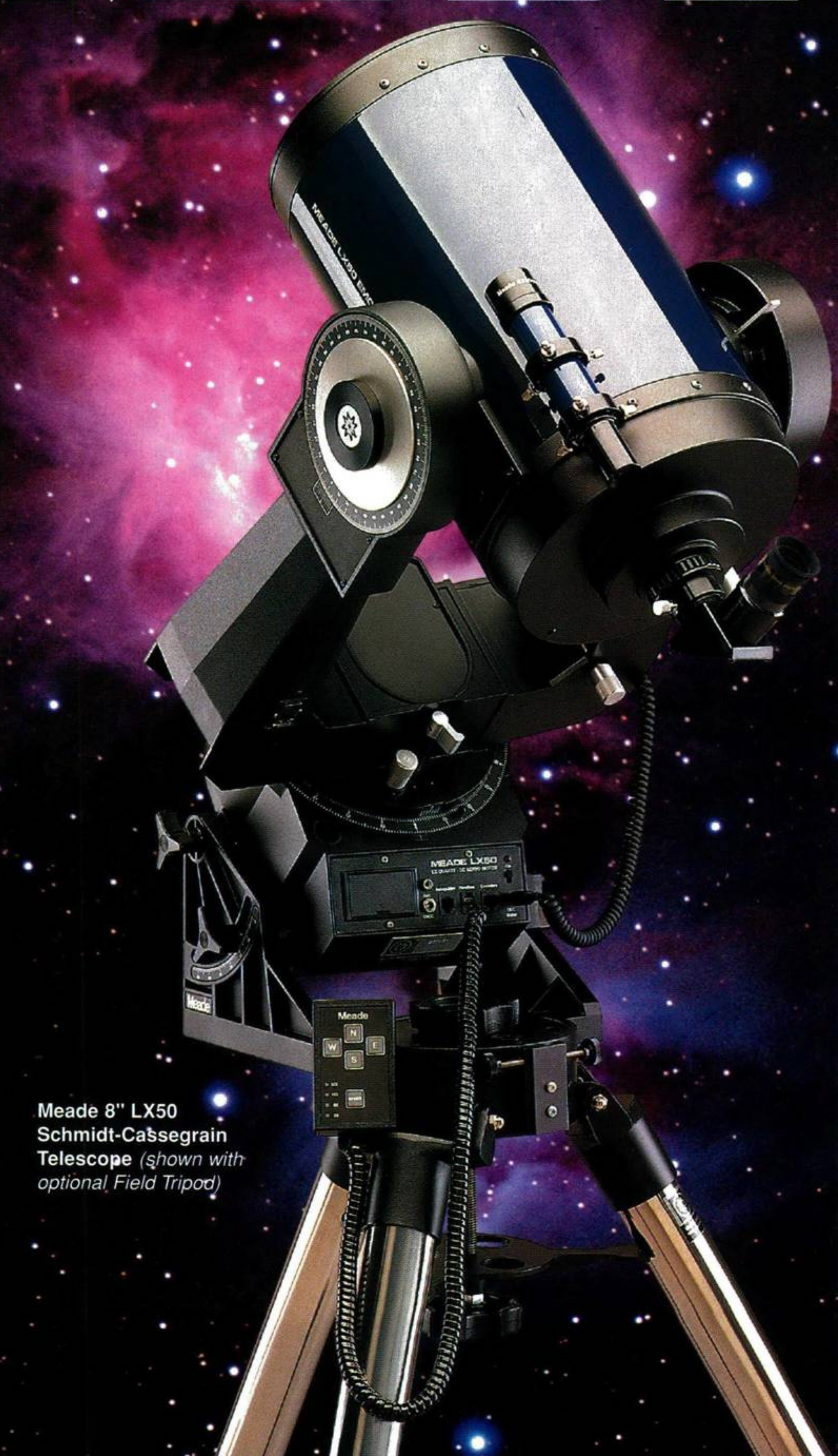
SPECIFICATIONS: 7", 8", and 10" LX50's — Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(shown above)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



Meade 8" LX50 Schmidt-Cassegrain Telescope *(shown with optional Field Tripod)*

MEADE LX200

The largest-selling serious telescopes in the world.

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. *Standard-equipment includes:*

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **LX200 High-Precision Pointing**™ is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive**™ routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The compact, optional #1812 Electronic DC Adapter allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's — Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

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MEADE LX200 EMC
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Meade 10" LX200 Schmidt-Cassegrain Telescope

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Now with Series 4000 Super Plössl 26mm eyepiece as *standard equipment!* Consider these features:

Series 4000 SP26mm Eyepiece (1.25"): The premium SP26mm ocular permits all Meade Starfinder Dobsonians to perform absolutely to their maximum capabilities. This $80 eyepiece is now **standard-equipment** on all Meade Dobsonians.

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: The same strong, spiral-wound Sonotubes™ used on Starfinder Equatorials *(right)*, tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

$270 Dobsonian Deluxe Accessory Package...only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

- 1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*
- 1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*
- 2 - **Meade Series 4000 Super Plössl 9.7mm and 26mm** multi-coated eyepieces — premium-grade eyepieces for high-resolution lunar, planetary, and deep-space observing. *(reg. $79.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $269.80!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

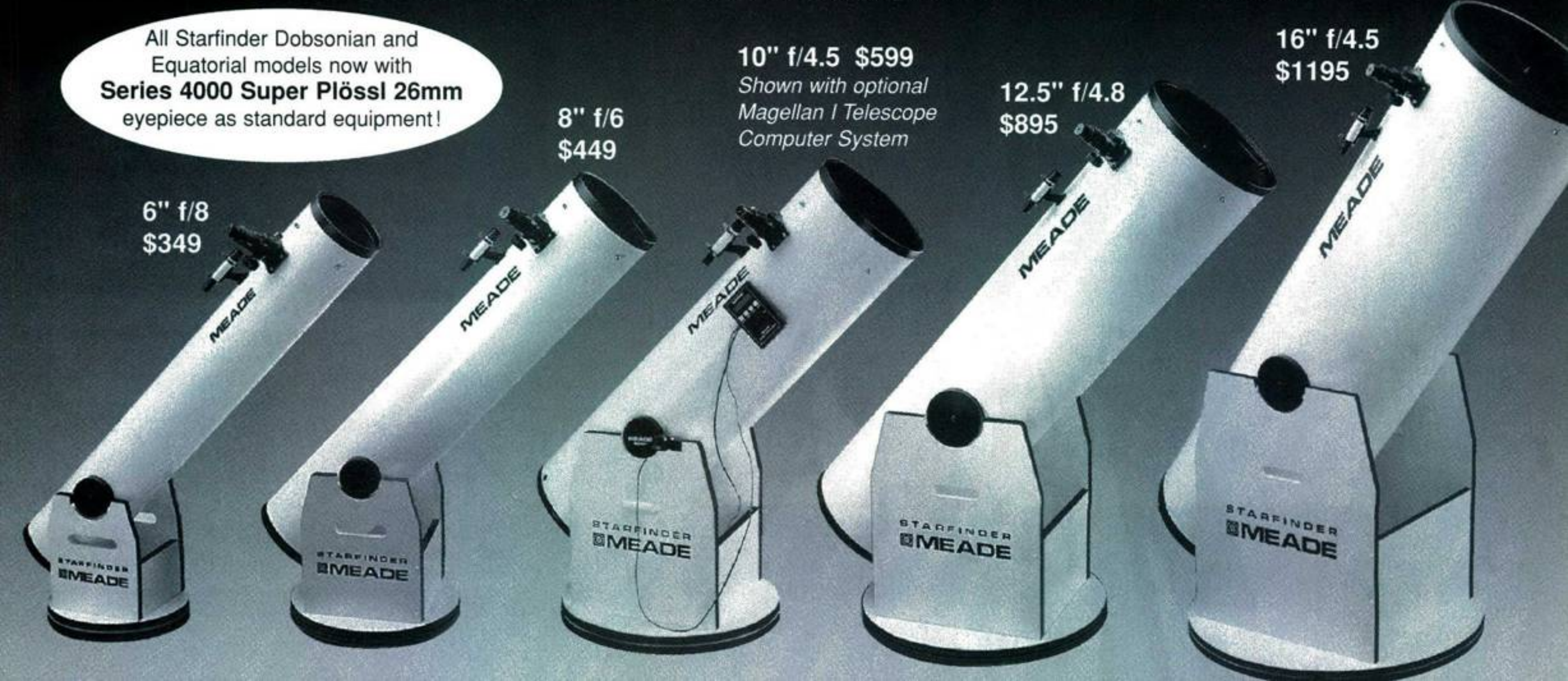
7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***



MEADE
STARFINDER EQUATORIALS

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy a Meade Series 4000 Super Plössl 9.7mm eyepiece ***for only $29.95!*** *Purchased separately, the SP9.7mm eyepiece sells for $79.95.*

With DC-powered drive systems for automatic tracking and Series 4000 Super Plössl 26mm eyepiece.

Professional-Grade Optical System: Hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Accessories and Components: Premium-grade multi-coated SP26mm eyepiece (1.25"); #637 6 x 30mm viewfinder with wide 7° field; strong, durable, spiral-wound optical tube with attractive white finish.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! For fully automatic tracking of celestial objects. Operates over 50 hours from 6 (user-supplied) AA-batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page).*

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.

#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.

#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

New 120-page 1999-2000 Meade General Catalog!

Write, call, or fax Meade Instruments for your free copy.

To Order: Contact your authorized Meade Advanced Products Mail-Order Dealer, below. Prices shown are suggested U.S.A. mail-order retail prices.

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

POCONO MOUNTAIN OPTICS, Moscow, PA.
Orders: 800-569-4323; Info.: 570-842-1500.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 312-332-2000.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

ADVANCED PRODUCTS DIVISION
Meade Instruments Corporation
The largest-selling telescopes in the world. ☐ *A NASDAQ company.*
6001 Oak Canyon, Irvine, California 92620 ☐ (949) 451-1450
FAX: (949) 451-1460 ☐ *www.meade.com*

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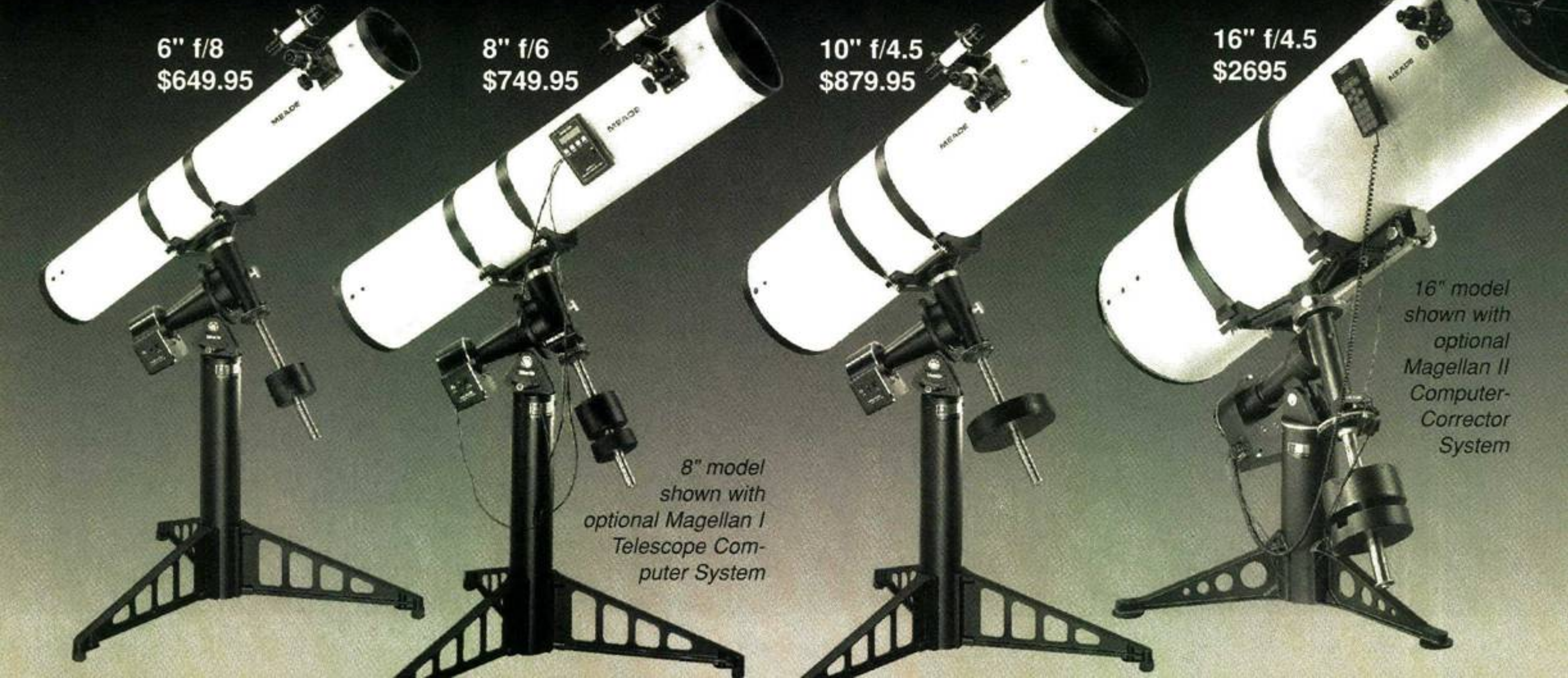
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



6" f/8
$649.95

8" f/6
$749.95

10" f/4.5
$879.95

16" f/4.5
$2695

8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

MEADE RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (4.54)
32mm (52°); **40mm** (44°)	each:	**99.95** (5.26)
56mm (52°; 2")		**199.95** (7.02)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture. **$129.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.73)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (5.26)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. **$149.95** (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

$79.95 (6.85)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 3000™ Plössls 50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm *(far right in photo)*, an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm** (44° field): **$79.95** (3.86)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (5.26)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (5.26)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

#911X
#910X
#908X

Series 4000 Oxygen-III Filters Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade *60-layer* interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces, 26mm dia.	**99.95** (4.54)
#910X–Threads into 2" eyepieces, 44mm dia.	**159.95** (5.26)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (4.54)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

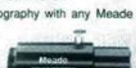
As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (5.26)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (3.86)

Variable Tele-Extender



For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with ***any*** brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camera film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XT or ST-7, or smaller; or visual observing with 1.25" eyepieces. **$149.95** (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XT, as well as ST-4 through ST-8; or for visual applications with 1.25" or 2" eyepieces. **249.95** (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.) **15.00** (3.86)

NEW!
MEADE
FLIP-MIRROR SYSTEM
MEADE
PICTOR

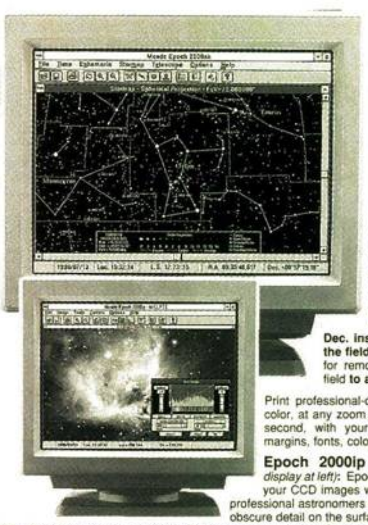
#644

MEADE
FLIP-MIRROR SYSTEM

#647

MEADE
FLIP-MIRROR SYSTEM
MODEL 647

Epoch 2000® Sky Software



The most powerful astronomical software ever made available can now be yours for only $149!

Epoch 2000sk *(upper display at left)*: Now you can use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** With star positions displayed as precisely as **0.01 arc second,** the Trapezium in Orion is no longer shown as a single point, as in other software, **but as four precisely oriented starpoints, just as they appear in the telescope.** No longer do you need to guess the R.A. and Dec. of an object located away from the field center, as in other programs: Epoch 2000sk dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely!

Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software *(lower display at left)*: Epoch 2000ip makes it easy to enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet. This powerful software includes virtually every technique available for image enhancement. Techniques that bring out detail totally invisible in your original image, transforming it from the ordinary to the spectacular.

EPOCH 2000sk Sky Software: 281,000 objects supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . . . **$149**

EPOCH 2000sk-CD Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM **179**

LX200 Interface Cable: for Meade LX200 operation by Epoch 2000sk **25**

EPOCH 2000ip Image Processing Software: Supplied on 3.5" discs for Windows 3.1 or higher; fully compatible with Windows 95 . . . . . . **$199**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

4000 f/3.3 CCD FOCAL REDUCER

NEW!

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture. **$149.95** (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

NEW!
MEADE
PLÖSSL
CCD FRAMING

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models and ST-4 through ST-8. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above)*. Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25". **$129.95** (4.54)

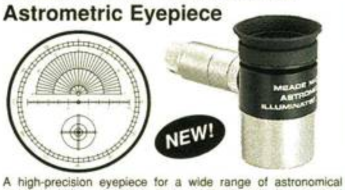
#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing. **$49.95** (4.26)

#64 T-Adapter for ETX®

Threads to the photo port of all ETX-90 and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera. **$34.95** (3.86)

MA12mm Illuminated Reticle Astrometric Eyepiece



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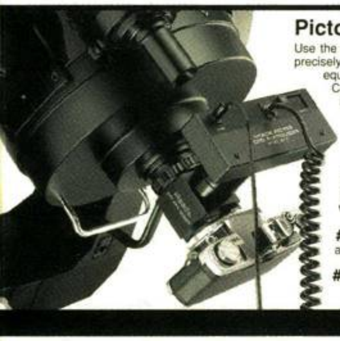

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#520 Electronic Relay: Use with Pictor 201XT on telescopes without autoguider connector or with retrofitted drive corrector. **95.** (5.28)

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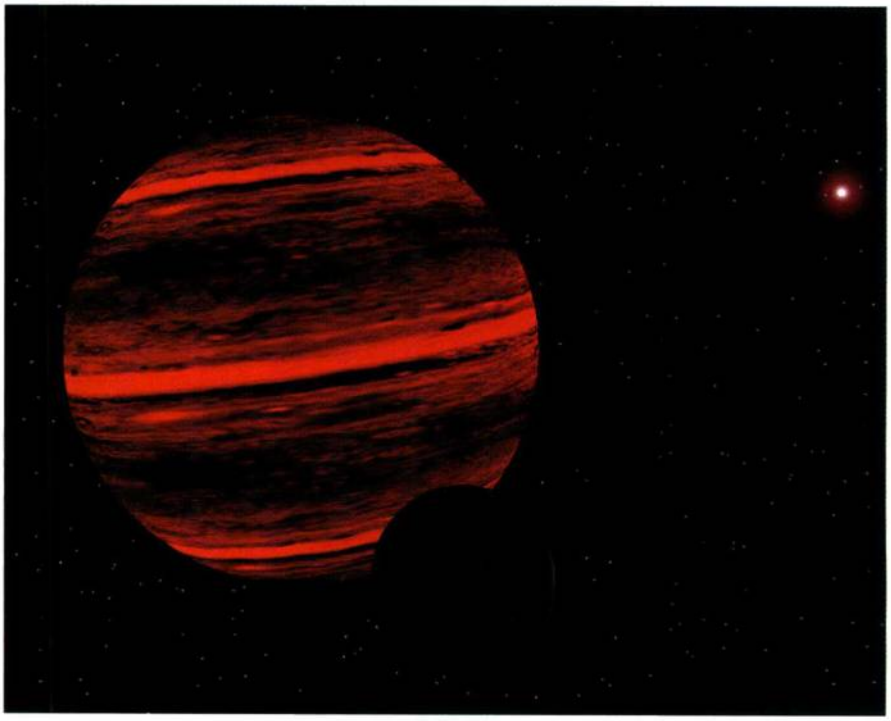
The Lithium Test

Robert Naeye's article about brown dwarfs ("The Little Stars That Couldn't," August 1999) was not the first one in which I have found a mention of the so-called lithium test for brown dwarf status. But I did not find any explanation of just how and why "as stars fuse hydrogen . . . they destroy lithium." What fusion reaction path produces lithium? And how do stars (presumably second generation and later) destroy it? Is this really confirmed, or just a widely accepted hypothesis for lack of a better one? — *Patrick L. Lilly, Cheyenne Cañon, Colorado*



Unlike stars, brown dwarfs don't destroy lithium in their cores. John Whatmough

The so-called "lithium test" was developed primarily by Rafael Rebolo's research group at the Instituto Astrofisico in the Canary Islands. This test was the first, clear-cut observational distinction between brown dwarfs and stars whose distances from Earth were not well measured. The test relies upon the definition of a brown dwarf as a gravitationally condensed object that does not undergo fusion reactions in its core. (This definition is the subject of some debate; see page 46, July 1999.)

Two fusion reactions can operate at relatively low temperatures: one that converts deuterium into helium, which happens during the early life of all brown dwarfs, and the other referred to in the letter above. That reaction is part of the standard sequence of fusion reactions known to power main sequence stars and happens fairly rapidly, completing the destruction of lithium in low-mass stars in about 50 million years and in the highest mass brown dwarfs (65 to 80 times the mass of Jupiter) within 250 million years. Brown dwarfs less massive than 65 Jupiter masses keep their initial lithium content forever, because their cores never develop the necessary temperatures and pressures to ignite this fusion reaction.

Why should what happens in the deep cores of brown dwarfs and very low-mass stars have any bearing on astronomers' observations of their atmospheres? Stellar structure theory shows that these objects are fully convective, meaning that their contents are constantly churning. So what lies in their atmospheres one day may be inside their cores within a few decades. Thus, the abundances of chemical elements in the star or brown dwarf are expected to be uniform from the core to the atmosphere. In contrast, more normal-sized stars such as the sun are not fully convective, and some of the initial lithium is trapped in the atmosphere and can be observed. This lithium can never reach the core of the star where it would be destroyed rapidly by fusion reactions. These ideas are well confirmed by observational data. — Ben Oppenheimer, California Institute of Technology

Cassini's Nuclear Risk

David Grinspoon has certainly convinced me that Cassinni's nuclear risk is among the top 1,500 things of which I should be deathly afraid. It's right up there with alien invasions and Alar-treated apples.

To put it in perspective, I invite you to consider those atmospheric nuclear tests that Grinspoon's mom protested. These bombs were almost all powered by 10 to 20 pounds of plutonium. Only a small fraction of this plutonium, much less than half, is fissioned in the explosion. The rest is vaporized and dispersed in the atmosphere.

Over the years of atmospheric testing, the amount of plutonium released into the air dwarfs the potential release from Cassini. I must have missed the reports of the billions who died from these tests, though there probably were a few deaths due to acute exposure to radiation from fallout that is unrelated to the plutonium risk. So those who postulate negligible risk even in the event of an accident are on more solid scientific footing.

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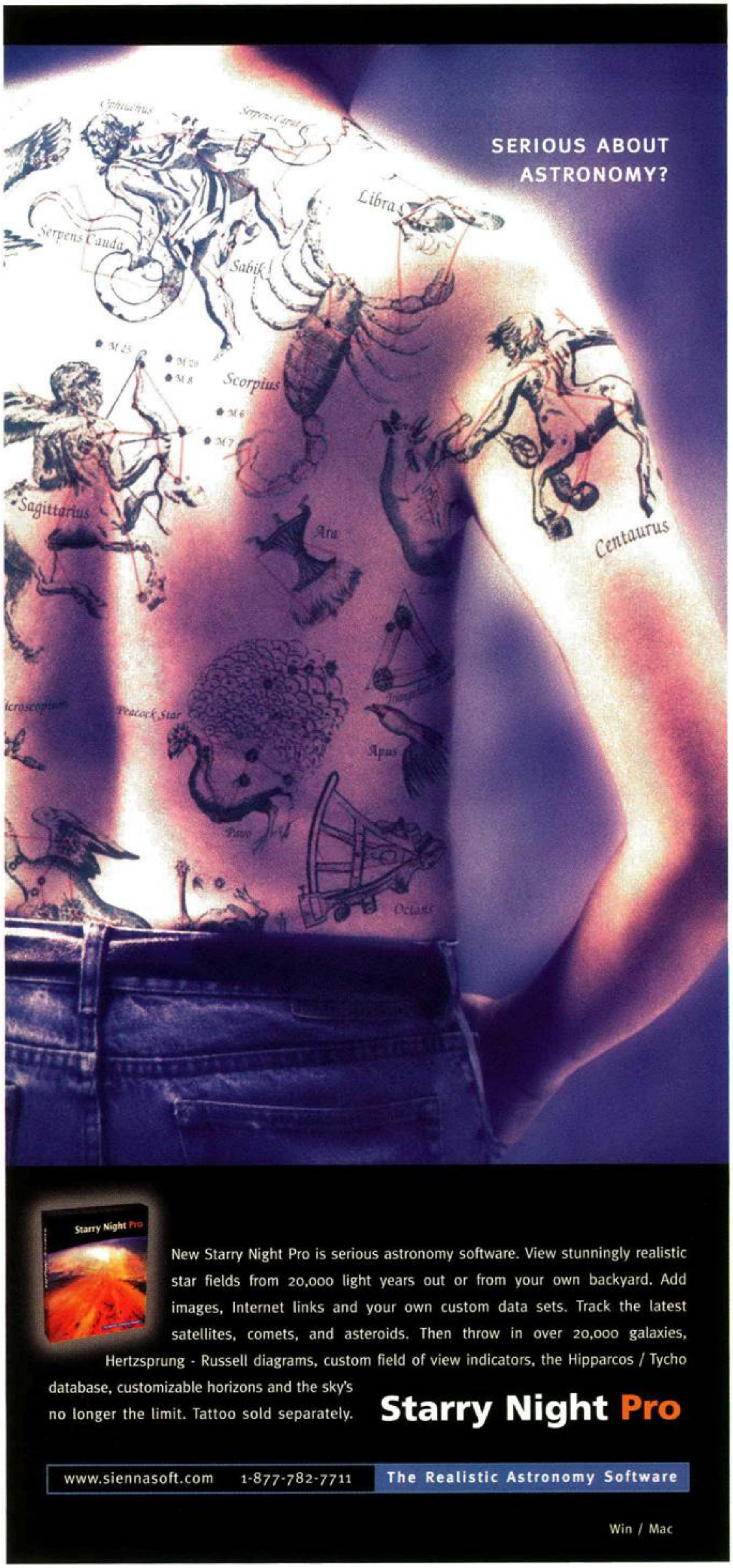

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Should we change a sound engineering design because a few misguided people have strong feelings? — *Albert Schwartz, Port St. Lucie, Florida*

Corporate Funds For NASA?

With despair and dismay I read of the cancellation of NASA's cometary mission. It was another disappointment in a long list brought on by budget constraints.

Why can't NASA augment its meager funding with corporate sponsorship? Instead of standing before Congress for its lifeblood, NASA could be out in the corporate world making presentations in boardrooms.

Perhaps NASA could take a page from NASCAR. Companies spend millions to put their company logo on the sides of race cars. NASCAR puts on a show that people want to see, and thus companies are willing to spend the cash so fans will see their name.

NASA also puts on a show that people want to see. Look at the interest the public showed over the Mars rover. Americans are far ahead of the government in their desire to explore space. With such a large potential audience, it seems natural for corporate advertising to make an appearance.

I can hear a cry go up from the scientific purists, but it will be commerce that will really open up the planets and ultimately take us to the stars. I have no trouble with seeing space shuttles painted in corporate colors. The external fuel tank would look splendid in Coca-Cola livery.

Perhaps there's a regulation or law that a government agency can't be, even partially, self-supporting.

I can see it now: "A new satellite was launched this morning aboard Miss Budweiser. . . ."

Why not "Captain Flash Gordon and his crew prepare for their eighth day aboard the McShuttle?" — *Robert Reynolds, Yuma, Arizona* A

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C114-HD
C102-HD

HD SERIES TELESCOPES – two refractors – an 80mm (3.1") with a focal length of 900mm (f/11) and a 102mm (4.0") with a focal length of 1000mm (f/10); two Newtonians – a 114mm (4.5") with a focal length of 900mm (f/8) and a 150mm (6.0") with a focal length of 100mm (f/7).

All models come standard with a 6x30 finderscope and a premium 20mm Plössl 1¼" eyepiece.

OPTICS – all **HD** series telescopes have diffraction limited, premium optics manufactured to Celestron's uncompromising standards. The star images are classic textbook Airy disks. The Newtonians have multicoated optics and the refractors are fully multicoated to provide higher light transmission yielding bright, high contrast images.

The refractors have very good color correction. The 150mm Newtonian uses a state-of-the-art proprietary optical design incorporating an auxiliary correcting lens to reduce various aberrations, flatten the field and allow the tube length to be shortened – and it is superior to most fast parabolas.

MOUNT AND TRIPOD – the **HD** telescopes use the CG-4 German equatorial mount. It is a precision, heavy-duty mount which is upgraded and much better than the older polaris mounts.

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The superb optics with rigid mount and tripod of the **HD** telescopes allow you to enjoy awesome details of our moon such as craters, rills and mountain ranges; Saturn and its rings; Jupiter with its belts and moons; Mars, Venus and Mercury; deep-sky objects such as galaxies, nebulae, double stars and star clusters.

C150-HD
C102-AZ
C80-HD

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- Aluminum Optical Tube
- High Quality, Smooth Dob Mount
- Standard 1¼" Accessories: 25mm SMA Eyepiece (36x) and Focuser
- 5x24 Finderscope
- Collimation Tool Standard
- Weight: 18 lbs.

Celestron's Star Hopper 4½ is unique, small Dobsonian telescope that's great for both your own use and for gift-giving. The mount and telescope tube are shipped fully assembled in one box, ready for you to beg observing immediately.

4½"

8"

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- Unique Balance System
- 25mm SMA Wide Angle Eyepiece - 1¼"
- 5x24 Finderscope
- 1¼" Rack and Pinion Focuser
- Collimation Tool - very useful and unique to Celestron
- Made in the U.S.A
- Weight: 6" @ 39 lbs., 8" @ 55 lbs.

6" and 8" Dobs offer one of the best values for an astronomer. Large primary objectives and affordable prices allow first-time astronomers to explore deep-sky objects with ease.

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In summary, *Astronomy Magazine* says, "Star Hopper® is a milestone on the road toward a better commercial Dobsonian telescope. Star Hopper's innovative mirrors, mirror cell and adjustable altitude bearings, combined with its crisp, sharp images more than meet what every Dobsonian owner hopes to have in an easy to use, backyard telescope."

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SATELLITES

Uranus May Edge Saturn in Moon Count

▶ With the discovery of two new companions in Uranus's midst — possibly its 19th and 20th moons — Uranus may become the planet with the most natural satellites. Saturn has 18, Jupiter 16, Neptune 8, Mars 2, and Earth and Pluto have one each. The "probable new satellites of Uranus," announced in a July 27 Circular of the International Astronomical Union, are 12 to 18 miles (20 to 29 km) in diameter. Temporarily designated S/1999 U 1 and S/1999 U 2, the moons currently orbit about 16 million and 6 million miles (25 million and 10 million km), respectively, from the center of Uranus.

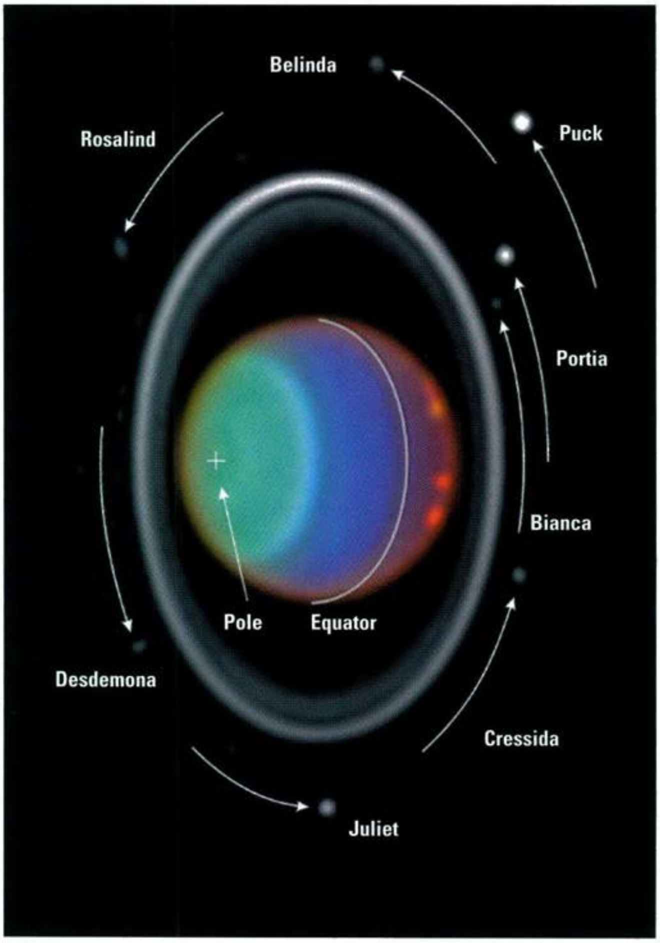
Uranus orbits the sun every 84 years and rotates once every 17 hours, 14 minutes with its axis tilted over 98°. Its five major satellites — Miranda, Ariel, Umbriel, Titania, and Oberon — revolve around the planet in the same direction that it spins. The candidate satellites appear to be "irregulars" with highly inclined and probably quite eccentric orbits.

The bluish-green planet was the only gas giant with no known irregular satellites. That changed in October 1997 when astronomers working at Palomar Observatory in southern California discovered two irregulars — Caliban and Sycorax. The irregular orbits of the two candidate moons and the pair found in 1997 indicate they are likely "captured" by Uranus, says codiscoverer Matt Holman of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Massachusetts.

"After finding two satellites during a very brief search in 1997, we felt the odds of a new discovery were in our favor if we could cover enough of the sky around Uranus," explains J. J. Kavelaars of McMaster University in Canada, who is a member of both the 1997 and the 1999 discovery teams. Kavelaars and Holman, with team leader Brett Gladman, Jean-Marc Petit, and Hans Scholl from the Observatoire de la Cote d'Azur in France, used the Canada-France-Hawaii Telescope in Hawaii, whose field of view covers a patch of sky as big as the full moon.

Unfortunately, the newest two objects were observed on only three nights over a three-week baseline. More observations were to be made this fall to confirm that the two new objects are uranian moons and not Centaurs, asteroidal objects orbiting the sun at a distance coincidentally close to that of Uranus. "Until a longer arc of observations is available — at least a few months' worth — it will not be certain if they are satellites or Centaurs," says Philip Nicholson, a Cornell University astronomer and editor of *Icarus*, a journal devoted to planetary astronomy.

— Ray Jayawardhana



Uranus orbits the sun once every 84 years while tilted 98° on its side. It has 18 known satellites, including eight inner moons shown in this image. Two objects soon may be added to the uranian family of satellites. NASA, JPL

NONSTANDARD CANDLES

Some Supernovae Flashier than Others

▶ Astronomers are finding more stellar explosions called type Ia supernovae that remind them of misfiring automobile engines that suddenly speed up or "ping" and "knock."

"Actually, there is a lot of work being done on this in the combustion-physics community for the automobile industry, and it is all very relevant to type Ia supernovae," says University of Arizona astrophysicist and type Ia supernova expert Philip Pinto. "If we

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Spotting scopes are thought of for terrestrial applications. However, with apertures of 80mm and larger they can be used as - altazimuth telescopes for astronomy, imaging lenses, guidescopes and piggyback lenses among others. Featured here are just two models of exceptional capability.

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C5 Spotting Scope – A large 5" aperture, 1250mm f/10 Schmidt-Cassegrain optical system. The multicoated diffraction limited optics are made in the U.S.A. The f/10 provides for a variety of photographic endeavors and makes possible its light weight (6 pounds) and compact size (11 inches). Standard is a 26mm multicoated Plössl eyepiece - 1¼" 45° erect image diagonal and 8x20 erect image finderscope.

C5 Spotting Scope

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completely understood all of that combustion physics we'd all probably be working for BMW designing better engines."

While a well-tuned, clean-burning engine produces carbon-dioxide exhaust, the nuclear fusion reactions starting with carbon and oxygen in a type Ia supernova produce radioactive nickel. The supernova fusion process begins when a dense, compact, white-dwarf star that is drawing gas from a neighboring red-giant star reaches a mass of about 1.4 suns. Theorists agree that as a white dwarf accumulates mass that approaches this so-called Chandrasekhar limit of 1.4 solar masses, the increasingly compressed core of a white dwarf ignites.

The extraordinary luminosity of such an event is due to the release of energy from radioactive nickel as it decays. However, the apparent variability of a supernova's "burning front" during its journey to the star's surface profoundly affects a supernova's visual horsepower. For example, if the burning front moves outward too slowly, less nickel is produced and the supernova can be a dud, dimmed by a factor of 10. Likewise, if the burning front moves out faster than normal, more radioactive nickel is produced, and the supernova can be twice as bright as the norm.

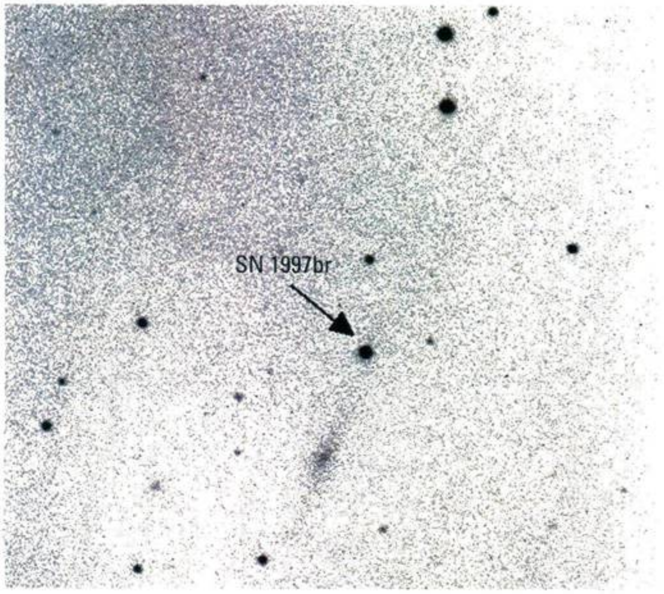
In a paper published in the June issue of *The Astronomical Journal*, a team of 10 astronomers led by Weidong Li of the Beijing Astronomical Observatory (BAO) and the University of California at Berkeley reported the discovery of an unusually bright type Ia supernova, SN 1997br, about 80 million light-years away in the constellation Corvus. SN 1997br is similar to three other unusually bright type Ia supernovae: SN 1991T, SN 1997cw, and SN 1998ab. The team also discovered SN 1997cn, which resembles the earlier-discovered dim SN 1991bg.

Theoretical astrophysicists can't explain all the variability. "This field of astronomy is wide open," says Alexei Filippenko of the University of California at Berkeley and one of the coauthors. "It seems that expansion of the exploding star is what quenches this burning front and makes it wimp out and not burn all the way to nickel. Or, it could be that there are white dwarfs that don't reach the Chandrasekhar limit before they explode."

Astronomers don't often use automotive metaphors to describe supernova behavior. Instead, they refer to type Ia supernovae as uniform "standard candles," and use their distances from Earth to determine the expansion rate of the universe. In many of those studies, teams of astronomers correct for brightness variations of "peculiar" supernovae before including them as part of their cosmic-distance analyses. "They're not all 100-watt light bulbs," says Filippenko.

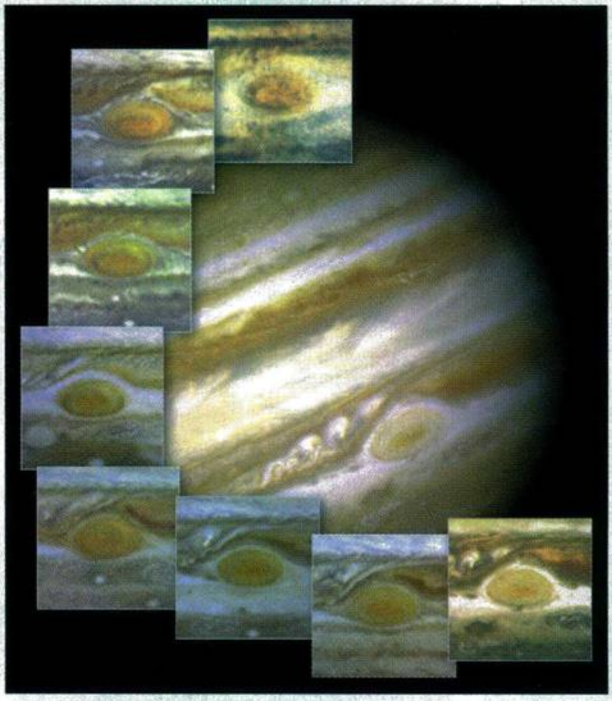
— Rex Graham

SN 1997br, which is about 80 million light-years away in the spiral galaxy ESO 576-40, was a "peculiar" type Ia supernova that shined much brighter during its two-month outburst than most of its type Ia supernova brethren.



Weidong Li

GREAT RED SPOT



Hubble Heritage Team (STScI/AURA/NASA)/Amy Simon (Cornell Univ.)

JUPITER'S GREAT RED SPOT is one of the first features that comes to mind when many astronomers think of our solar system's largest planet. These Hubble Space Telescope pictures, taken between 1992 and 1999, show how the gargantuan, oval storm changed shape, size, and color during that period. First seen in 1664, the counterclockwise-rotating storm twice as large as Earth may be long-lived due to the fact that Jupiter is a gaseous planet: It lacks a solid surface, which would dissipate the storm's energy.

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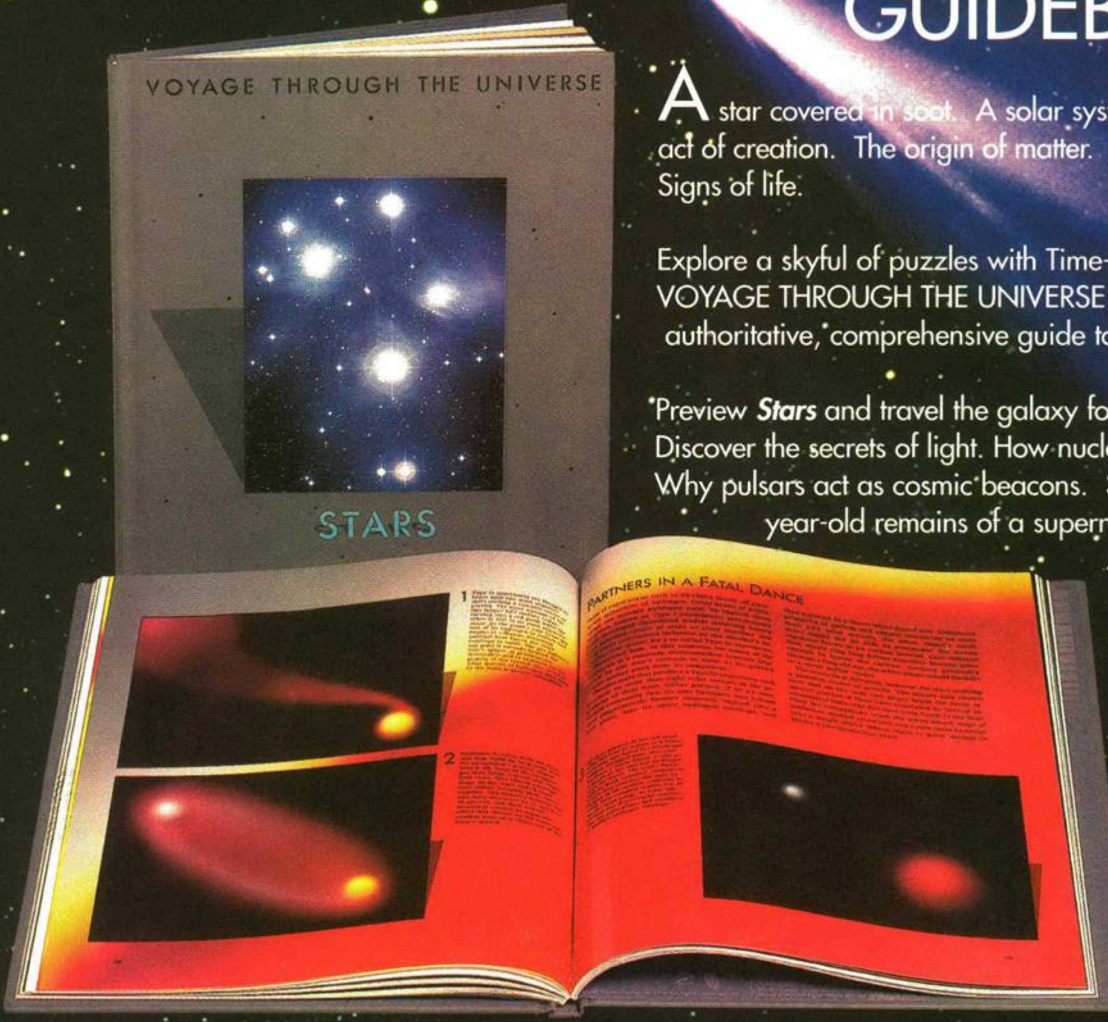

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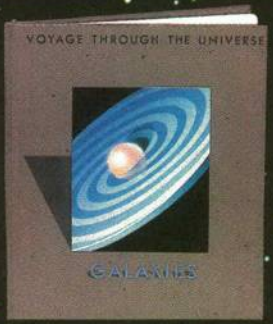

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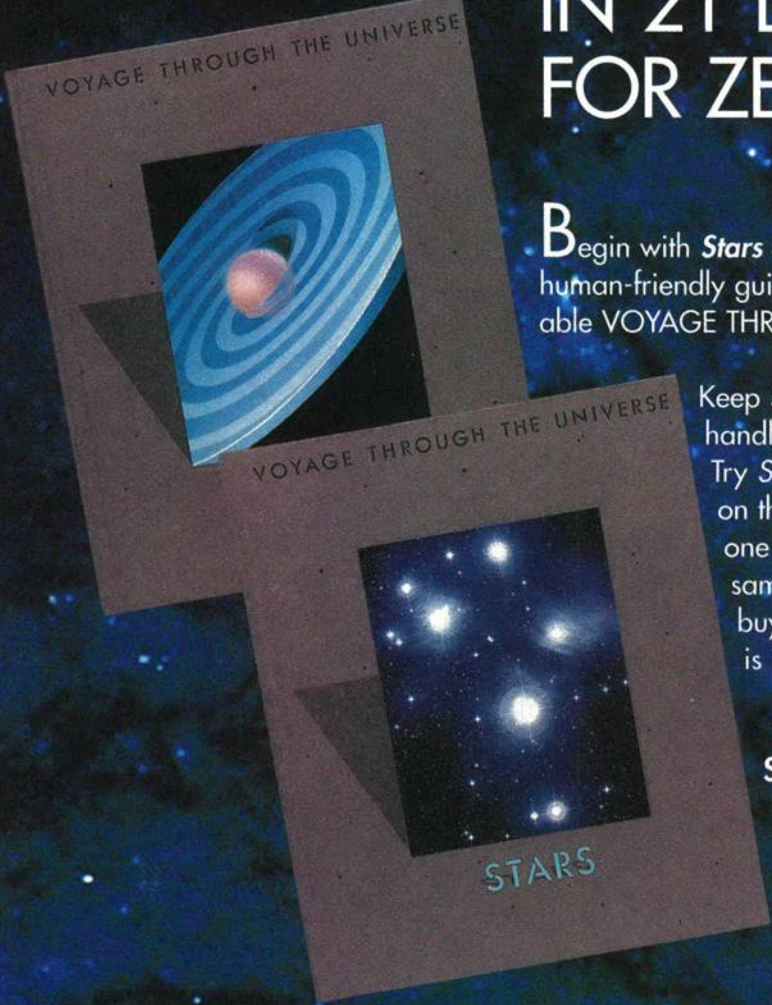

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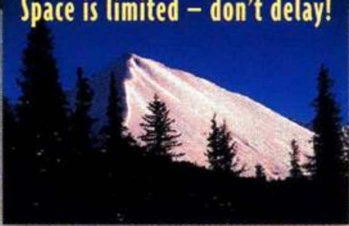

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RISK ASSESSMENT

Spin Control for Asteroid Hazards

▶ The next time a newly discovered asteroid appears to be heading toward Earth, astronomers hope to avoid scaring the public if there actually is little chance of an impact. To accomplish that, Richard Binzel, an astronomer at the Massachusetts Institute of Technology, has devised a system for rating asteroid-impact hazards that is modeled after the Richter scale for earthquakes. The goal, says Binzel, is to avoid prompting sensational news coverage of the discoveries of near-Earth objects and "help the public determine what level of concern is appropriate."

The effort at astronomical spin control comes after several examples over the years of asteroid-impact fears that subsequently proved to be overblown. A recent example involved the rogue asteroid 1997 XF_{11}, which some astronomers initially thought would come dangerously close to Earth in 2028, possibly even hitting the planet. Worldwide concern arose after astronomer Brian Marsden, director of the International Astronomical Union's (IAU) Central Bureau for Astronomical Telegrams and the Minor Planet Center, issued a scientific bulletin and press release to encourage more observations of XF_{11}. A day after the news release, scientists at the Jet Propulsion Laboratory in Pasadena, California, ruled out an impact in 2028, but not before the media seized on the mix-up. The flip-flop prompted a writer for the *New York Post*, a tabloid newspaper, to pen, "You can kiss your asteroid goodbye."

Gaspra, Deimos, and Phobos would receive a Torino rating of 0, but Earth-crossing asteroids may someday pose great risk to Earth. NASA, JPL

Binzel's idea to assign a realistic level of concern to asteroids that come close to Earth was adopted at a June IAU meeting in Torino, Italy. The IAU approved using a "Torino scale" ranging from 0 (no chance of impact) to 10 (a global catastrophe such as the impact 65 million years ago that may have killed off the dinosaurs). Voluntary IAU guidelines call for astronomers to review their potentially alarming calculations with an independent review panel before making an announcement about the risk to the public. If these steps are followed, excessive asteroid headlines may become as rare as impacts themselves.

— STEVE NADIS

LIGHT POLLUTION

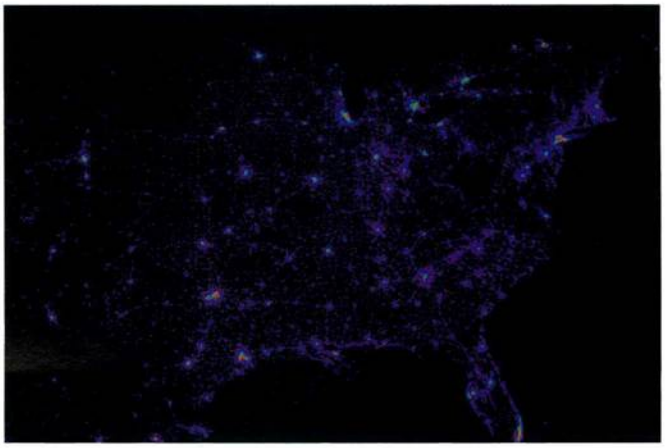
Defense Satellite Detects Waste

▶ Astronomers using declassified data from a U.S. Department of Defense satellite have found millions of dollars wasted — not on gold-plated hammers or toilet seats — but on light pollution. The problem arises from outdoor light fixtures that allow light to escape upward instead of directing it downward onto streets, sidewalks, and parking lots. Assuming electrical costs of $0.10 per kilowatt-hour, a team of researchers estimated that the annual waste amounts to $1.5 million in Boston, Massachusetts, $7.15 million in Kansas City, Missouri, and $13.6 million in New York City. But virtually every municipality wastes money on light pollution, say the researchers.

Of course light pollution is a major concern of astronomers. It increasingly floods the night sky in the vicinity of all cities, dimming nighttime views of the Milky Way Galaxy to little more than an array of pale points of light scattered across a washed-out sky. "These problems are global in scale and effect and long-term in nature," says Johannes Andersen, General Secretary of the International Astronomical Union (IAU). "International efforts are needed to resolve them, as the United Nations already has done for the oceans and the continent of Antarctica."

A team of Japanese and American astronomers announced the results of its study in July at an

This satellite image shows light pollution across a swath of North America. NGDC, NOAA



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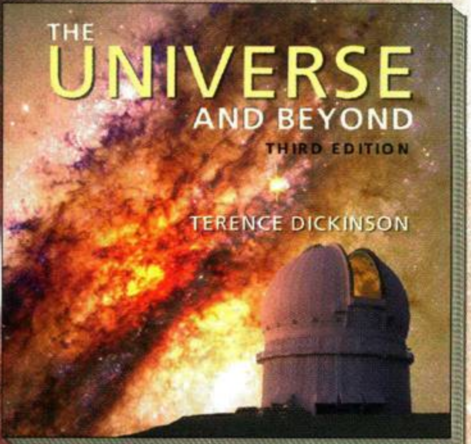
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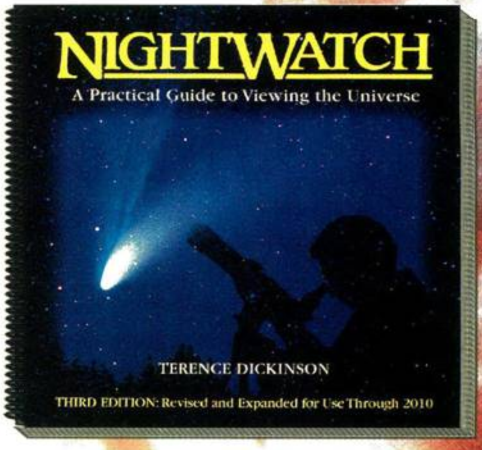
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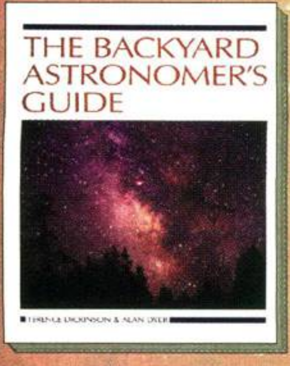
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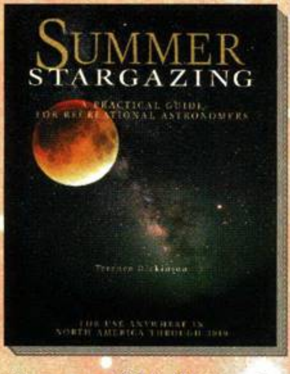
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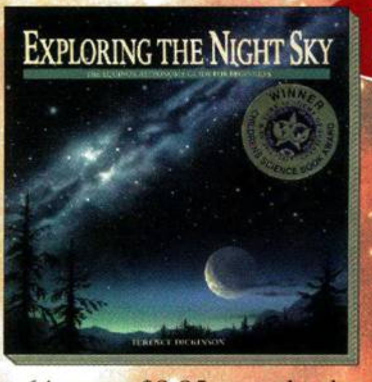
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IAU-sponsored meeting in Vienna, Austria, titled "Preserving the Astronomical Sky." The team was led by Syuzo Isobe of the National Astronomical Observatory in Tokyo, Japan, and Chris Elvidge of the U.S. National Oceanic and Atmospheric Administration's National Geophysical Data Center in Boulder, Colorado. The team used declassified data from the Defense Meteorological Satellite Program (DMSP), a program capable of distinguishing low levels of visible and near-infrared light at night.

The team analyzed satellite data collected from October 1994 to March 1995. It was able to distinguish between clouds, lights, glare, or a combination of the three. The astronomers said municipalities could improve nighttime visibility, safety, and security and save money by directing lighting downward rather than up into the sky.

— Phil Harrington

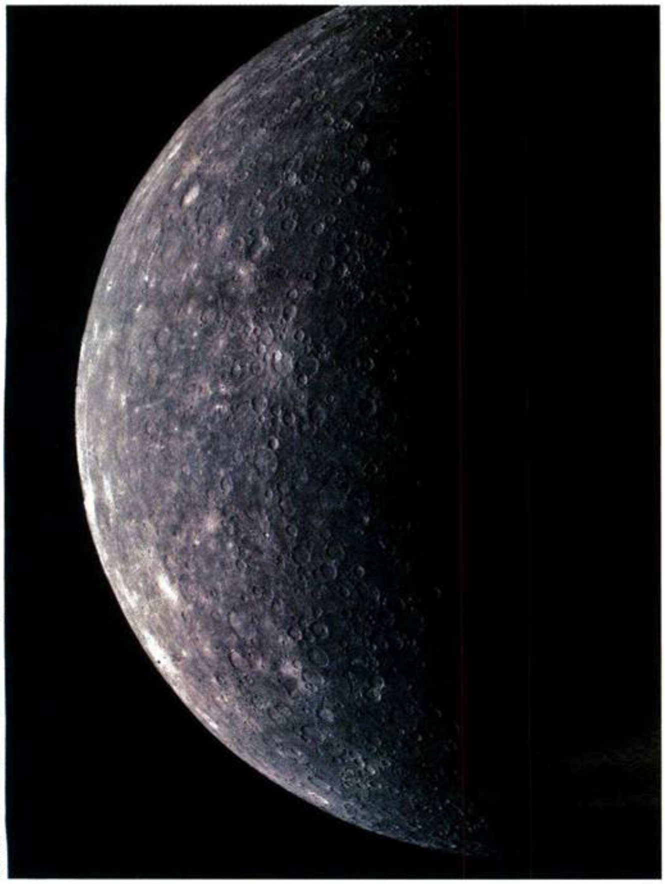
UNFINISHED WORK

Returning to Mercury

▶ NASA has decided to return to Mercury after a three-decade absence to make the first comprehensive map of the pockmarked planet. The Mercury Surface, Space Environment, Geochemistry, and Ranging (MESSENGER) mission will carry seven instruments into orbit around the closest planet to the sun. It will send back the first global images of Mercury and study its shape, interior, and magnetic field.

MESSENGER, with a planned launch in spring 2004, will be NASA's first mission to Mercury since the Mariner 10 flybys in 1974 and 1975, which provided information on less than half the planet. MESSENGER's challenging flight plan begins with two Venus flybys, then two Mercury flybys in January and October 2008, and a later orbital tour of Mercury beginning in September 2009.

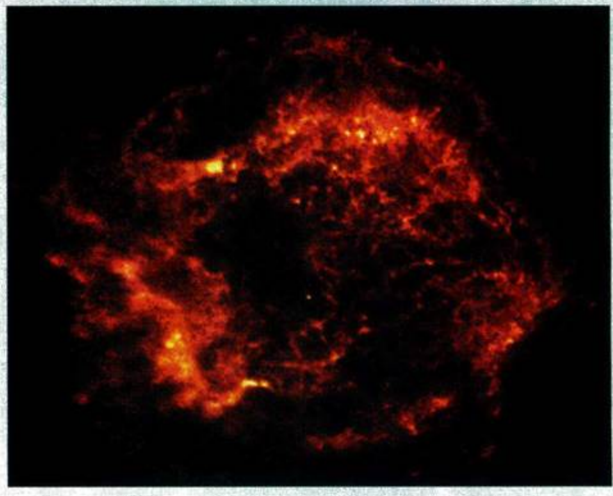
The mission will seek answers to a number of questions, such as whether Mercury has water ice in its polar craters, what is the origin of Mercury's high density, and what is the



Mark S. Robinson (Northwestern University)

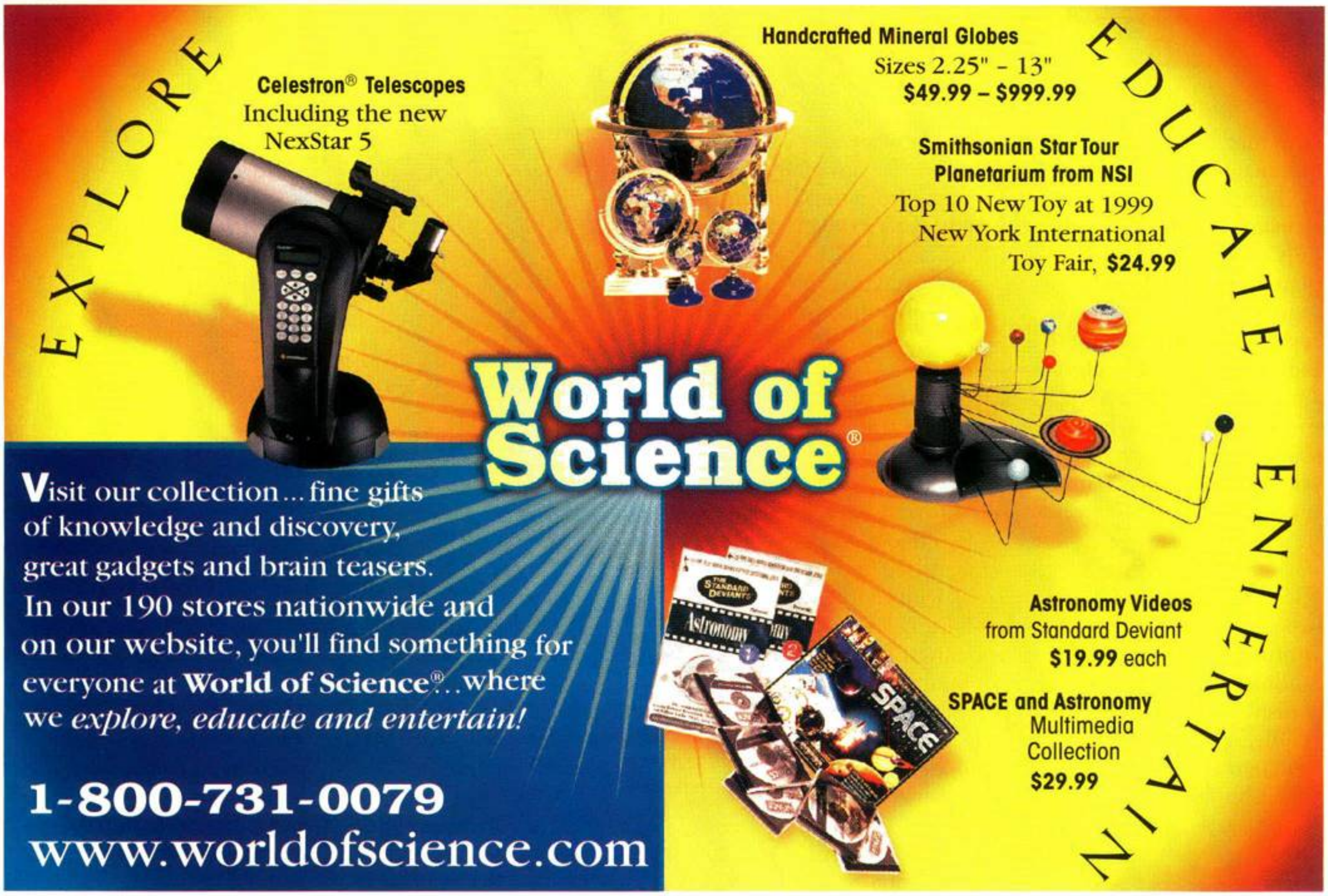
Mercury, the innermost planet, is the least understood of the terrestrial (rocky) planets.

CHANDRA FIRST LIGHT



NASA/Chandra X-ray Observatory Center

CASSIOPEIA A, A BRIGHT SUPERNOVA REMNANT about 10,000 light-years from Earth, was the first image released from NASA's $1.5-billion Chandra X-ray Observatory. The image gives astronomers their sharpest x-ray view of Cas A, which formed when a star exploded roughly 320 years ago. The explosion spewed material into space, and as the debris plowed into surrounding gas and dust at 10 million miles per hour, it generated shock waves that created a 12-light-year-wide bubble of 50-million-degree x-ray-emitting gas. Chandra's ultrasharp resolution, 10 times better than any previous x-ray telescope, enabled it to see a bright clump near the center of the remnant, which might mark the location of a neutron star or black hole left by the explosion. "History teaches us that whenever you develop a telescope 10 times better than what came before, you will revolutionize astronomy," says Edward Weiler, NASA's Associate Administrator of Space Science. "Chandra is poised to do just that." The image demonstrates that Chandra is in excellent health and that its mirrors and instruments are performing as expected.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structure of Mercury's core and magnetic field.

Twenty-five years after Mariner 10 visited Mercury, only 45 percent of the planet has been photographed. Those images reveal a cratered surface like that of the moon. Slightly younger plains sit between the largest old craters. Many scientists think that the plains are volcanic. This interpretation is reinforced by a slightly different color of the plains than the ancient craters, which may indicate a different rock composition. But because landforms indicative of volcanism are too small to be visible in Mariner 10 pictures, the origin of the plains remains uncertain.

THE MOON

Fuel for Fusion Power Abundant on Lunar Maria

▶ If fusion is harnessed to produce electricity on Earth, the moon may become a hot property for an efficient fuel — an isotope of helium called helium-3. New analyses of images from the Clementine spacecraft's 1994 visit reveal rich caches of the rare gas on the lunar surface. It could be strip-mined to provide enough of the isotope to supply the United States' energy needs for thousands of years.

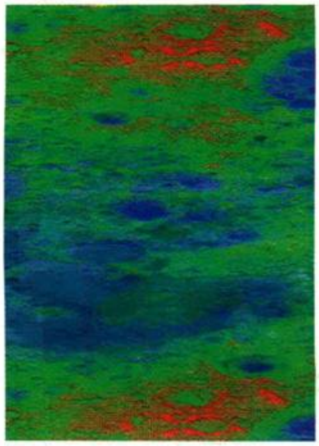
"If someone wants to go get it, we can give them some options where they should look," says planetary scientist Timothy Swindle of the University of Arizona. Helium-3 would be the cleanest fuel of choice for potential 21st-century fusion reactors because its reaction is efficient and produces little residual radioactivity. However, helium-3 is scarce on Earth because primordial traces of it continually evaporate into the atmosphere and space. On the contrary, the moon has an ever-growing supply, continually imported on the solar wind.

Scientists knew from rock samples retrieved by Apollo astronauts that the mineral ilmenite has a structure that acts like molecular Velcro, capturing and trapping high-speed helium gas. Ilmenite is composed of iron, titanium, and oxygen.

Clementine's spectroscopic mapping in visible and ultraviolet light allowed Swindle and his colleagues at the University of Hawaii and the U.S. Geological Survey to identify lunar lava flows, or maria, rich in the mineral ilmenite. Three of the ancient flows are on the farside and three are on the nearside of the moon.

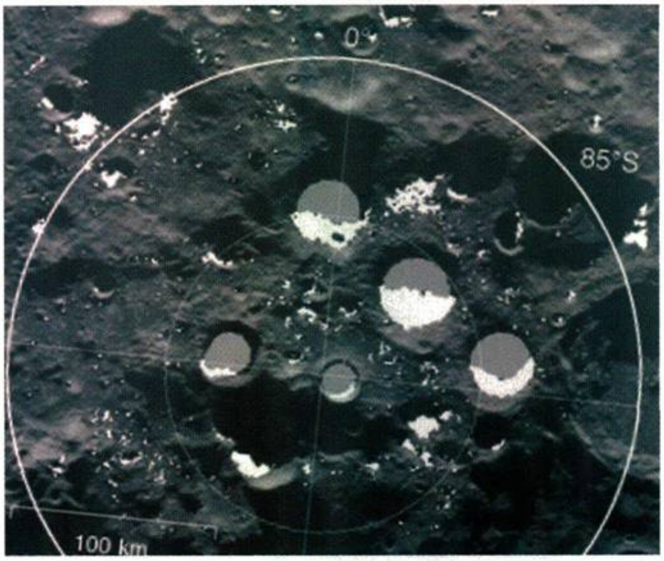
The sites range from about 50 to 500 miles (80 to 800 kilometers) across. The nearside is richer in helium-3-absorbing ilmenite; however, the farside is exposed to more solar wind. Lunar scientists expect to refine their maps with new elemental-composition data produced by the Lunar Prospector spacecraft.

The helium-3 concentrations are about 10 parts per billion in the rock. While that sounds puny, the team calculates that the moon could yield 1 million metric tons of the gas, enough to provide electrical power to the United States for two millennia. — DAVID GRAHAM



Helium-3 deposits have been detected in these maria or "seas" of the moon, with relative concentrations of the rare gas shown in green (high) and red (higher).

J. R. Johnson, (USGS); T. Swindle (University of Arizona); P. Lucey (University of Hawaii)



J. L. Margot/Cornell University

The Lunar Prospector satellite was aimed at the base of this crater on the moon's south pole, but astronomers were unable to spot a dust cloud created by the kamikaze crash.

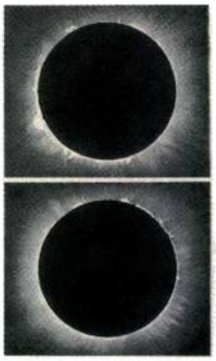
DUST AND ASHES

Satellite Hits Lunar Crater

▶ For the cratered moon, the July 31 impact of the Lunar Prospector satellite must have felt like a trifling bump. Traveling at 3,800 miles (6,080 km) per hour with a bevy of instruments and a famous planetary scientist's ashes aboard, the $63-million satellite plunged into a south polar crater and vanished. It was a last-ditch, nothing-to-lose attempt to squeeze more science out of the mission by sending up a cloud of lunar dust and examining it for signs of lunar water.

Unfortunately, neither the telescopes of hundreds of amateur astronomers nor 20 land- and space-based professional telescopes saw any dust. Hitting lunar soil at a 6° angle, the 354-pound (161-kg) satellite may have simply bounced across the floor of the crater. It also could have sent a shower of dust at an angle into the interior wall of the crater, making it too low to be detected from Earth.

"You don't play roulette unless you want to win, even if the odds are against you," says a discouraged David



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Goldstein, a Prospector mission scientist and associate professor of aerospace engineering at the University of Texas in Austin. "We tried and it didn't cost much.... It was better than just letting it fall randomly."

Earlier measurements of the moon's poles by Prospector led scientists to estimate that up to 220 million tons of water, in the form of ice crystals, are present in the top 18 inches (46 cm) of lunar soil. The presence of water for drinking and power generation would make an extraterrestrial base easier to establish.

A small vial of ashes from planetary scientist Eugene Shoemaker, who died in a 1997 automobile accident, was carried by Prospector and now rests on the moon as well. "Our family feels very good about it all. We can call him 'the man in the moon,'" says the scientist's widow Carolyn Shoemaker. "Gene would have been so pleased that the Prospector mission went so well and about using the satellite to the hilt." — NEAL SINGER

EXTRASOLAR RESEARCH

Distant Planet Discovered With 1-Year Orbital Period

▶ Planet hunters using a 55-inch (1.4-m) telescope at the European Southern Observatory (ESO) in La Silla, Chile, have found evidence for yet another planet orbiting a nearby star. The latest discovery brings the total number of extrasolar planets discovered indirectly to about 21 as of August 1999. The latest planet discovered, which is at least 720 times more massive than Earth, has an orbit that most closely resembles Earth's than any of the previously discovered extrasolar planets.

The massive planet orbits Iota (ι) Horologii, a sunlike star about 56 light-years from Earth in the southern constellation Horologium the Clock. The discovery is the result of a survey of 40 solar-type stars that was initiated in 1992. A team led by ESO astronomer Martin Kuerster inferred the planet's presence from its parent star's tiny to-and-fro movements along our line of sight. The star's regular "wobble" is caused by the gravitational pull of the orbiting planet.

While this indirect technique to find extrasolar planets is routinely being used by several research groups, detecting a planet with a 1-year orbital period presents a special challenge. The ESO team verified that the slow wobble of Iota Horologii is due to the effects of a planetary companion and not due to an observational artifact from the movement of Earth around the sun.

To complicate matters, the star is visible to the telescope in Chile for only part of the year. So Kuerster's team caught the star in nearly the same orbital position year after year. The observers waited for several years to sample a large enough portion of its orbit before they were sure they had found an extrasolar planet. — RAY JAYAWARDHANA

Another Organic Molecule Found on Pluto

Pluto's surface is composed of solid nitrogen, methane, and carbon monoxide. Now, astronomers have added solid ethane (which has two carbon atoms and six hydrogen atoms) to the frozen mixture. The ethane, discovered with the 8.3-meter (327-in) Subaru Telescope, may be a component of the original primordial material from which our solar system was formed. Or the ethane may have been produced by the reaction of ultraviolet light with methane, which has one carbon atom and four hydrogen atoms. For more, go to http://www.astronomy.com/horizon.html.

Subaru Telescope

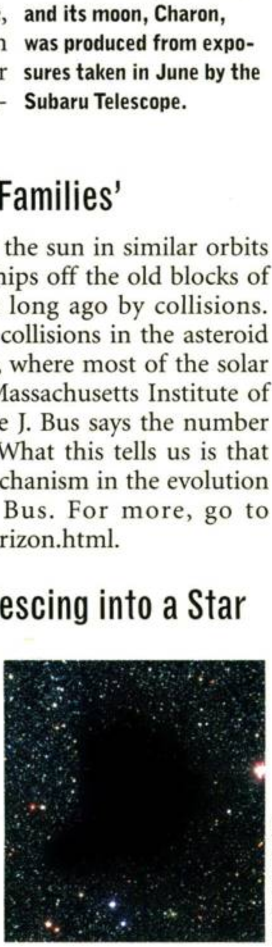
This color image of Pluto and its moon, Charon, was produced from exposures taken in June by the Subaru Telescope.

Asteroids Can Orbit as 'Families'

Groups of asteroids that circle the sun in similar orbits can actually be "families" — chips off the old blocks of larger asteroids broken apart long ago by collisions. Investigating the aftermath of collisions in the asteroid belt between Jupiter and Mars, where most of the solar system's asteroids are found, Massachusetts Institute of Technology astronomer Schelte J. Bus says the number of families is now up to 19. "What this tells us is that collisions are an important mechanism in the evolution of the asteroid belt," says Bus. For more, go to http://www.astronomy.com/horizon.html.

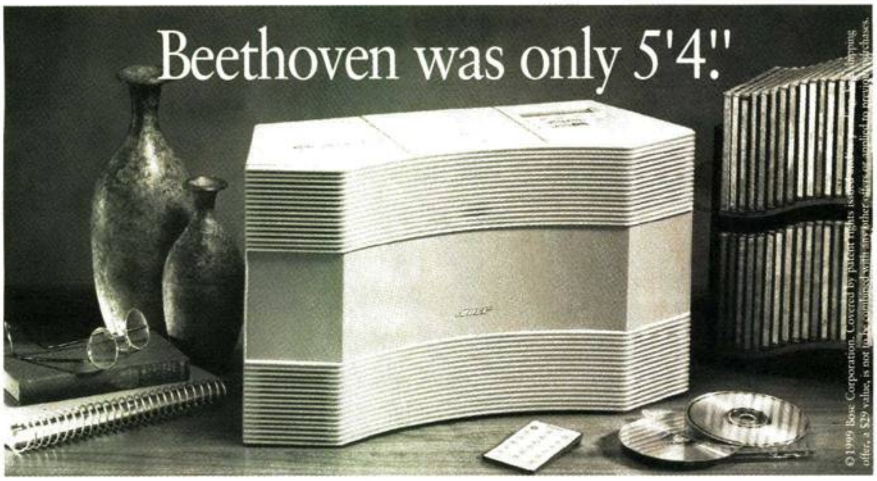
Dark Cloud Caught Coalescing into a Star

A team of astronomers has captured the very earliest stages of a "dark cloud" — the coldest astronomical object in the universe — possibly becoming a new star and planetary system. The dark cloud, also known as a dark globule, is called Barnard 68 and is about 500 light-years from Earth in the constellation Ophiuchus. "We have an outstanding example of a cloud that appears to have just initiated collapse to form a star, and we can study the structure in detail," says a team member, astronomer Elizabeth Lada. For more, go to http://www.astronomy.com/horizon.html.



Elizabeth Lada, ESO

This dark globule in the Milky Way, Barnard 68 (B68), appears to be in its very earliest phase of collapse. It has a diameter of only 7 light-months.



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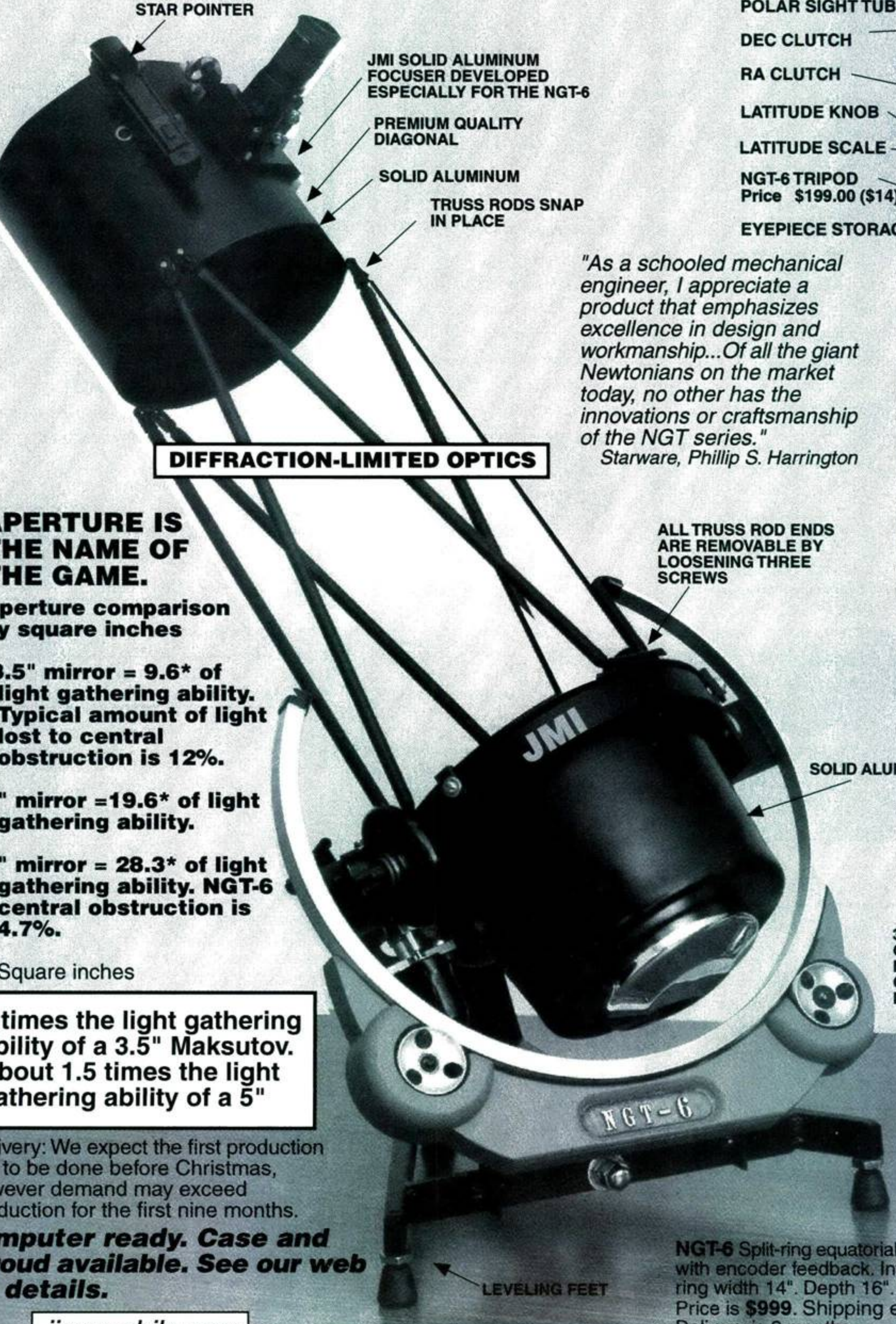
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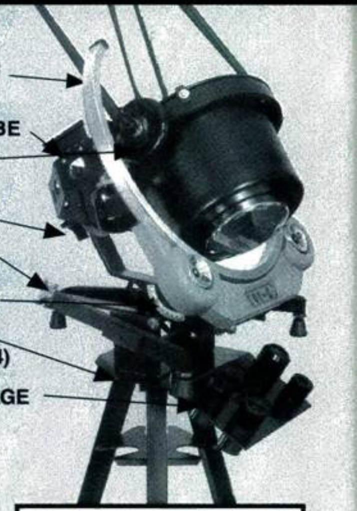
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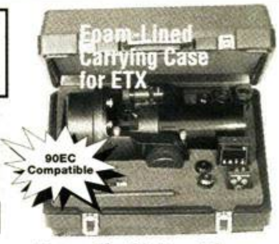

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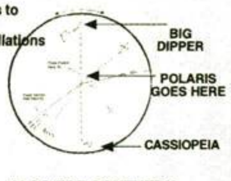

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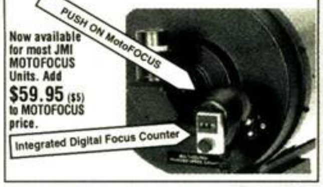

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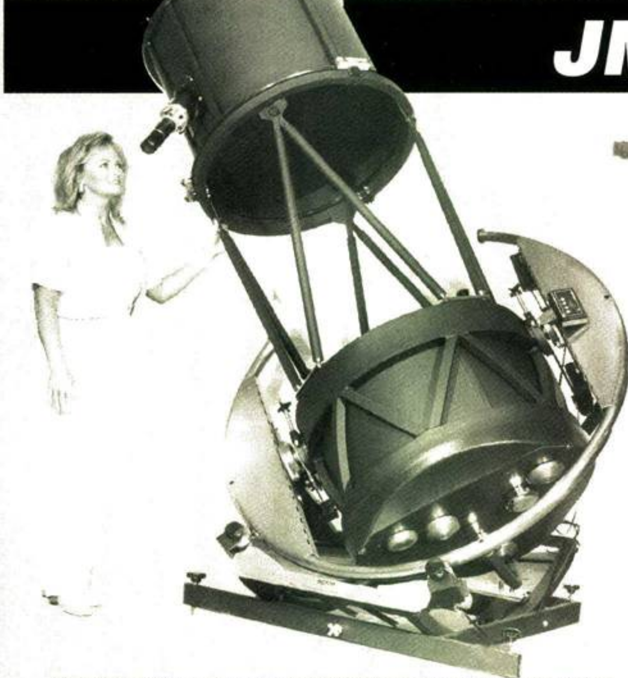

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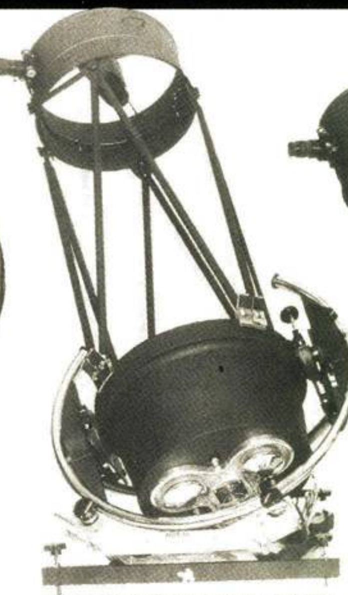

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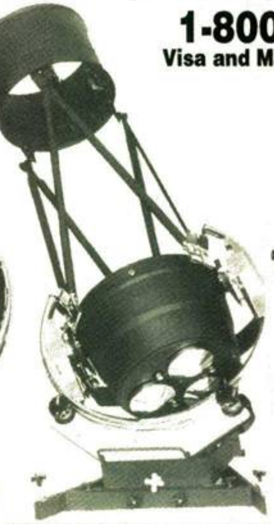

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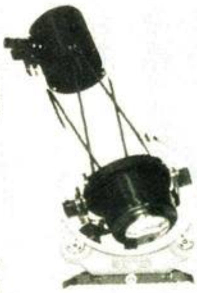

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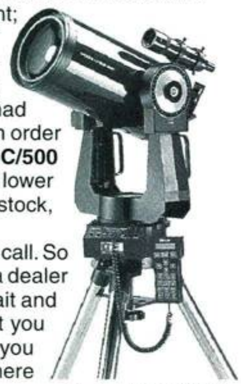

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Carl Sagan's Coming of Age

Humanity's first successful mission to another planet would help establish Carl Sagan's reputation.

by Keay Davidson

In the late 1950s and early 1960s, the Cold War had shifted to the frontier of space, and the United States was losing. With dizzying speed, the Soviet Union seized one cosmic "first" after another: the first animals in space, the first probe to contact another world (Lunik II, which slammed into the moon), the first astronaut (Yuri Gagarin), the first photos from the farside of the moon, the first female astronaut (Valentina Tereshkova).

Naturally, NASA was desperate to achieve a first — any first. All eyes turned toward the planet Venus. It was a brilliant world but a shy one, noticed usually in the wee hours by paperboys and milkmen who saw it hovering above the red ribbon of dawn or in the early evening by tired commuters who glimpsed it above the sunset and wondered if it was a UFO. Its brilliance owed to its perpetual cloud cover, beneath which — what? A humid jungle? A global ocean? A planet-wide Sahara raked by dust storms? More than a hundred times farther away (in a straight line) than the moon, Venus comes nearer to Earth than any other planet. It was the logical target for the first interplanetary space probe.

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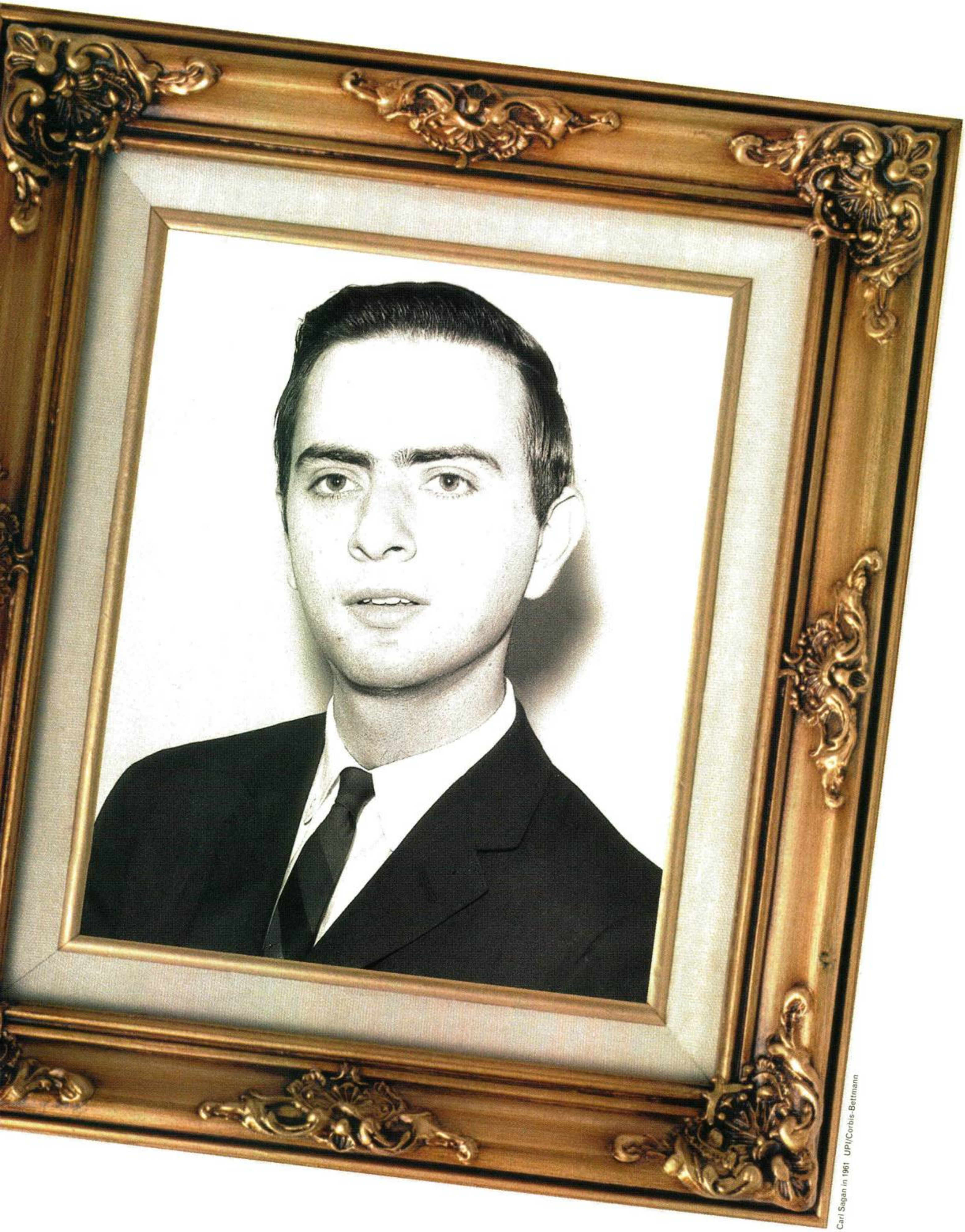


Carl Sagan in 1961 UPI/Corbis-Bettmann

Bill Ray

Carl Sagan in the late 1970s, at a time when he was becoming a celebrity for his *Cosmos* television series.

> "For me, it was just a dream come true. We were actually going to go to the planets!"

"For me, it was just a dream come true," Carl Sagan recalled. "We were actually going to go to the planets!" He was summoned to Caltech's Jet Propulsion Laboratory (JPL) in Pasadena to advise engineers designing the Mariner interplanetary probes about the kinds of observational instruments the probes needed and the key scientific questions the probes should be trying to answer. Meanwhile, the Soviets prepared to launch their own rockets toward Venus.

Sagan's first major article for a "mainstream" scientific journal appeared in March 1961, in *Science* magazine. "The Planet Venus" was a writing tour de force. Sagan's prose soared, and he unleashed his sense of humor (which somehow survived the magazine editors' blue pencils). He cited the numerous competing hypotheses about Venus: that it was a humid jungle, that it was swept by a carbonated ocean or a petroleum sea, that it was a desert with vast dust storms, or that it was some other form of wasteland. Thus, "those planning eventual manned expeditions to Venus must be exceedingly perplexed over whether to send along a paleobotanist, a mineralogist, a petroleum geologist, or a deep-sea diver." Even one of Sagan's most vocal critics, the famed astronomer E. J. Öpik, called it a "very stimulating and imaginative article."

The article presents Sagan's greenhouse model (see "The Greenhouse Effect," page 43) for the atmosphere of Venus, which he developed in the late 1950s as a doctoral student at the University of Chicago's Yerkes Observatory. It also contains fragments of his earlier, arm-waving speculations about life there. Native life was "unlikely," he wrote, but still, "conditions are much more favorable at higher altitudes, especially just beneath the cloud layer," where aerial microorganisms might drift on wind currents. He argued that space probes fired into the venusian atmosphere must be sterilized in advance, to make sure they would not contaminate any life-forms there.

Sagan would soon become embroiled in heated debates about the Mariner 2 probe, which would fly to Venus. One key question was whether Mariner 2 should carry a camera. Sagan and his colleagues argued long and hard about this. Nowadays, it is difficult to imagine a time when scientists didn't naturally place cameras aboard robotic spacecraft. We are accustomed to the spectacular images from, say, the Hubble Space Telescope, and from the Mars Pathfinder probe. These spacecraft are to space what Ansel Adams was to the American West.

But decades ago, few astronomers anticipated this breathtaking bumper crop of space imagery. Back then, telescopes offered only murky images of the planets. According to traditional accounts of modern astronomy, many astronomers regarded planetary astronomy as somewhat déclassé, a holdover from the Percival Lowell era. The real action was in studying galaxies, redshifts, stellar evolution, and the expanding universe. They half-consciously thought of planets as physical abstractions, as minor gravity wells in celestial mechanics calculations, rather than as places like, say, Yosemite or Yellowstone.

Besides, planetary probes were a nascent technology, with limited space and power resources. Cameras (it was thought) took up space needed for "real" instruments. In retrospect, space scientist David Morrison suggests dividing the debate into two camps, "the scientists" and "the explorers." The scientists preferred to make predictions about what would be found in the vicinity of a planet (such as a magnetic field of a certain intensity) and then send instruments designed to test those specific predictions. By contrast, the explorers — like Carl Sagan — expected to discover the *unexpected.*

"There was a prevailing view that cameras were a complete waste of time," Sagan later recalled. But he felt cameras were very important "precisely because they could answer questions we were too stupid to ask."

The "scientists," one might surmise, were numerocentric; they preferred highly *quantitative* data — numbers — to visual modes of interpretation. Many of them were physicists or engineers, which are number-hungry professions. They liked data they could feed into the increasingly popular electronic computers. To them, perhaps, pictures did not constitute real data. In contrast, Sagan had a certain aesthetic sensibility; he recognized pictures as both scientifically meaningful and worth having in their own right. In the decades to come, his stance would be repeatedly vindicated.

Time and again, space probes with cameras have exposed the *unexpected*. As a result, the solar system has proven to be far more complex than ever anticipated. With few exceptions, each new world seems unique unto itself, like a hitherto unknown epoch in the history of abstract art. Mere numbers cannot convey such richness. In space, a picture is worth a billion bytes.

Still, Sagan's colleagues had some justification for scoffing at his photo fervor. His definition of "unexpected" included things likelier to be proposed in *Astounding Science Fiction* than in the *Astrophysical Journal*. For example, he thought there might be occasional clearings in the venusian clouds, through which a Mariner 2 camera could peer and see — what? Perhaps the cloud-brushing mountains reported (erroneously, we now know) by earlier observers? Mountains atop which temperatures might be cool enough to support life? Likewise, he suggested that aliens once visited our solar system, stopped off at the moon, and left artifacts that might be visible to cameras. And in a 1963 speech, he advocated placing cameras aboard probes to Mars, partly because they might spot "many artifacts of advanced life-forms" — that is, martians. JPL officials overruled Sagan, and the Mariner 2 carried no camera to Venus.

Determined to beat the Soviets to Venus, NASA rushed to assemble the 447-pound (203-kg) Mariner 2 in less than a year. Space robots were relatively new things under the sun, and journalists struggled to describe this one. *National Geographic* called it a "dragonfly in space" and an "ungainly, skeletal spacecraft."

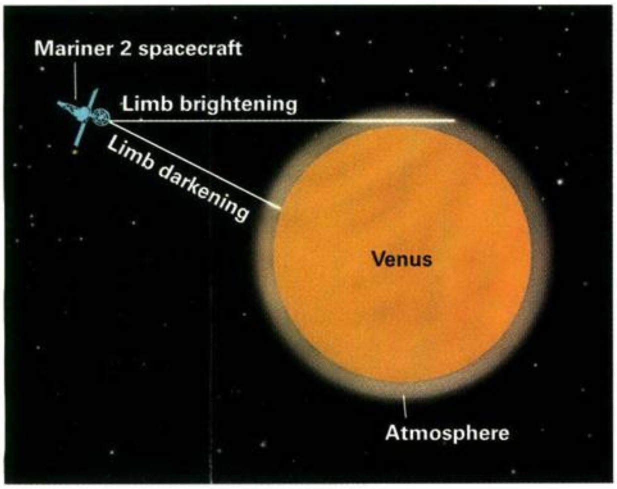
The different scientific teams had to move fast in developing their instruments. One of Sagan's Mariner 2 associates, Stillman Chase, recalls that the program manager had a block of lead on his desk and said: "This represents your instrument, and we're going to fly this instead if you don't finish on time." Sagan was, by his own account, "deeply involved" in developing one of Mariner 2's instruments, the infrared radiometer.

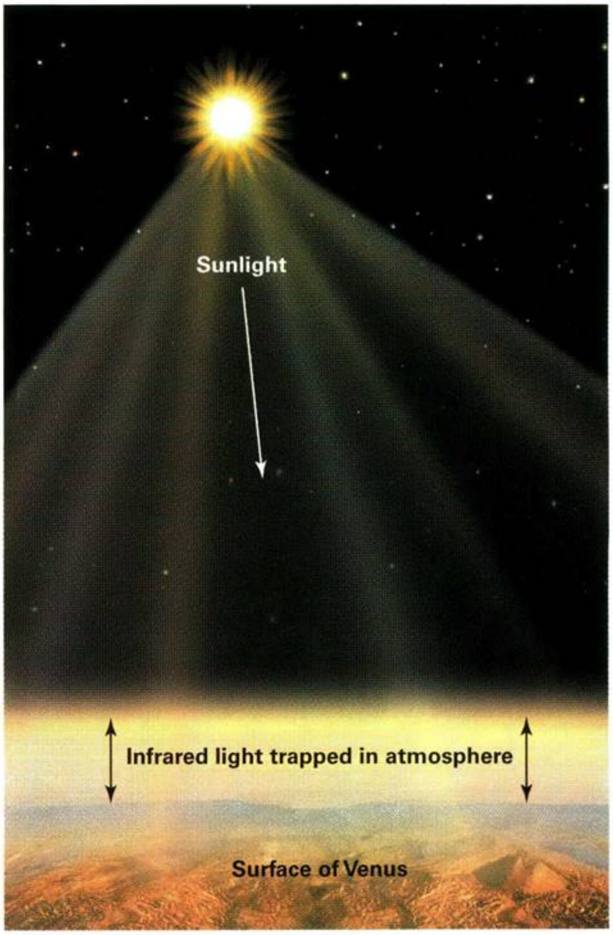
Much was at stake with Mariner 2 for Sagan. His credibility as a scientist rested, to a great extent, on his doctoral work predicting a greenhouse effect on Venus. That work could be instantly shot down if one of the Mariner 2 instruments, a microwave radiometer, flew by

THE GREENHOUSE EFFECT

As Carl Sagan predicted in graduate school, Venus's scorching surface results from a greenhouse effect gone amok (right). A small percentage of the sun's visible light penetrates the planet's thick, carbon-dioxide-rich atmosphere. The surface absorbs this energy and emits heat in the form of infrared light. But Venus's atmosphere absorbs this energy before it can escape into space, heating the surface to temperatures exceeding 850° F (450° C).

Was Venus's strong microwave signal coming from a hot surface, as Sagan surmised, or from an ionized region in the atmosphere, as other scientists thought? Mariner 2 would tell the tale (below). It detected limb darkening, meaning the microwave signal was coming from a hot surface, as implied by Sagan's greenhouse model. — *Robert Naeye*




Sunlight
Infrared light trapped in atmosphere
Surface of Venus

Astronomy: Elisabeth Rowan

Venus and observed a phenomenon called "limb brightening."

To be specific: As we have seen, some scientists disagreed with Sagan's belief that the intense microwave signal that had been picked up coming from Venus came from the planet's surface. Rather, they suggested that it came from a strongly ionized region far above the planetary surface. If this were so, then as Mariner 2 flew by Venus, the microwave signal should appear brighter toward the edge (limb) of the venusian disk than toward its center. This is called limb brightening.

Sagan's entire greenhouse theory would be ruined if Mariner 2 observed limb brightening, and his model of the venusian atmosphere would be irrelevant. But what if the probe observed "limb darkening," a weaker microwave signal toward the limb? This would support one of Sagan's crucial assumptions — that the signal came from the planet's surface. Darkening would not in itself prove his greenhouse model. There were other possible explanations at that time for Venus's apparent heat, including a suggestion by a Russian scientist that the heat came from radioactivity left over from a venusian nuclear war!

Such are the trials of doing science — it is often much easier to disprove a theory than to prove it. Theories are easily shot down, while truths are difficult to establish. Suppose, for example, that I observe hundreds of white swans. Does that mean I am justified in stating "All swans are white"? No, a black swan might show up tomorrow, and the sighting of a single black swan would disprove the all-swans-are-white hypothesis.

The observation of limb brightening would be Sagan's version of a black-swan sighting, the single, crucial blow that would undermine much of his doctoral toil (and with it, perhaps, much of his subsequent fame). He was nervously aware of this. To a great degree, his personal hopes for the future rode with Mariner 2 all the way to Venus.

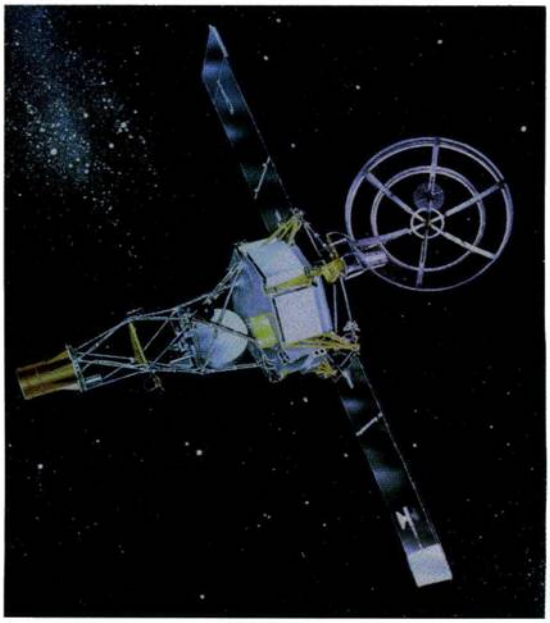
His anxiety at this time may explain why, for the rest of his life, he emphasized so eloquently the point, championed by the controversial philosopher of science Karl Popper, that no theory can be considered "scientific" unless one can conceive of a way, in principle, to disprove it. Pseudosciences and the occult, Sagan argued, fall far short of this standard. Often their hypotheses are too vague and slippery to generate predictions that can conceivably be tested. Obeying no firm rules of logic or research, pseudoscientists and occultists can always invent facile explanations for negative results (as when an astrologer, for example, attributes a failed prediction to "bad vibes"). As Sagan believed, a theory that cannot conceivably be disproved may make one feel warm and cozy inside; it may soothe much of life's pain and irrationality. However, it is not science.

In the early 1960s, as Tom Wolfe observed in *The Right Stuff*, the average American believed the following about U.S. space launches: "Our rockets always blow up." Actually, they didn't, not always; but many of them did. To cover its bets, NASA liked to launch two identical probes every time an interesting planet came within range. And sure enough, with almost amusing regularity, one of the twin probes would end up literally in the drink — blown up over the Atlantic Ocean after a wobbly takeoff from Cape Canaveral. Other probes traveled far into space, then stopped sending telemetry signals and were never heard from again.

NASA's first probe to Venus, Mariner 1, was launched on July 22, 1962; true to form, within seconds it veered off course, and a range safety officer ordered its destruction. Technicians later discovered the cause of the accident: They had

Sagan's entire greenhouse theory would be ruined if Mariner 2 observed limb brightening.

On December 14, 1962, Mariner 2 (right) inaugurated the age of interplanetary flight when it flew by Venus (left). The flyby helped launch the career of a young Carl Sagan.



NASA/JPL

accidentally omitted a single hyphen from the computer launch code. Naturally, everyone at Cape Canaveral was nervous on August 27, when the surviving Venus probe, Mariner 2, stood on its launch pad.

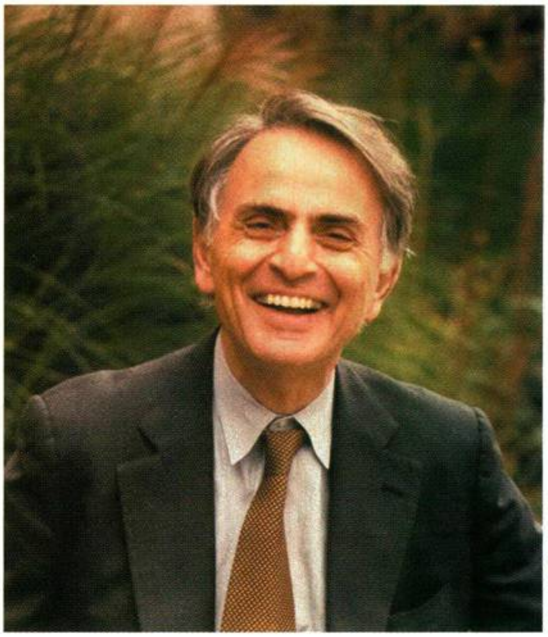
At 1:53 A.M. the Atlas D booster fired and ascended smoothly into space. The probe was scheduled to reach Venus before the Christmas holidays. In coming months, during its long journey to Venus, Mariner 2 endured many perils. Its instruments seriously overheated; its solar panels went haywire; it was reportedly struck by a small meteor.

As 1962 waned into autumn, though, a greater threat emerged: that come Christmastime, when Mariner 2 sailed by Venus and transmitted its findings home, no inhabitant of Earth would be alive to hear them. In October, U-2 overflights revealed that the Soviets were secretly installing nuclear-tipped missiles in Cuba. President Kennedy ordered Soviet premier Khrushchev to remove the weapons. Former Secretary of State Dean Acheson urged Kennedy to attack Cuba. Nuclear war appeared imminent.

Some scientists wondered if technical civilizations in general tend to self-destruct. If so, then the value of L (the average life span of a technical civilization in the galaxy) must be low, and SETI (search for extraterrestrial intelligence) is a waste of time: Few if any advanced civilizations will survive long enough for us to chat with them across the light-years of interstellar space. Neither will our own civilization, it seemed in late 1962, as schoolchildren rehearsed "duck and cover" exercises and families dug backyard bomb shelters. Never before in human history had the value of L appeared so low.

The December 14, 1962, Mariner 2 flyby was a success, a huge boost to America's beleaguered space program. Slowly, the Cold War seemed to be turning in favor of the United States. Only weeks earlier, President Kennedy had cajoled the Soviets into *withdrawing* their missiles from Cuba. In a span of two months, the United States had showed that it would not be intimidated, on Earth or in the solar system. The Soviets' Venus probe had stopped transmitting and disappeared, but NASA's technical prowess awed reporters. When, after a journey of 182 million miles, Mariner 2 flew tantalizingly close to Venus, one observer compared the feat to "sitting on a merry-go-round and shooting a bullet to hit a fast-flying sparrow over the horizon."

During the 35-minute flyby, the infrared radiometer observed Venus at wavelengths of 8.4 and 10.4 microns. It measured the temperature of Venus's upper atmosphere at –30° F (–34° C). The instrument detected no breaks in the cloud cover (hence Sagan's wished-for camera wouldn't have seen much). Meanwhile, the microwave radiometer scanned the face and limb of Venus at wavelengths of 13.5 and 19 microns. It detected limb darkening, as Sagan's greenhouse model had predicted; the intense radiation really did come from the planetary surface. In fact, Venus's surface was even hotter than anyone had thought — about 860° F (460° C). For all practical purposes, Venus was as hot as hell.


Michael J. Okoniewski

In the mid 1990s, Carl Sagan posed for this shot on the campus of Cornell University in Ithaca, New York.

Venus's surface was even hotter than anyone had thought, about 860° F. For all practical purposes, Venus was as hot as hell.

Neugebauer, Kaplan, and Chase reported their results in the March 8, 1963, issue of *Science*. Sagan, embroiled in a divorce at that time, is not listed as a coauthor. A footnote adds, however, "We acknowledge the help of Carl Sagan, who was an active participant during the conception and initial planning of this experiment."

For the rest of the 1960s, a few scientific diehards refused to believe the Mariner 2 observations. They insisted that Venus wasn't as hot as the space probe reported. The planet might be cool enough for life — even for glaciers. Battles over the true nature of Venus would continue for years.

Still, in early 1963, when Sagan moved to Harvard, the handwriting was on the wall. The Mariner 2 mission didn't simply inaugurate the age of interplanetary flight. Something was ending, too, something closer to the human heart than the human mind. A *New York Times* editorial recalled the old question of "whether or not life in some form existed on Venus and hence elsewhere in our solar system and possibly also beyond it. . . . The answer is a disheartening, disillusioning 'No! Not on Venus!' . . . The message from Venus may mark the beginning of the end of mankind's grand romantic dreams." A

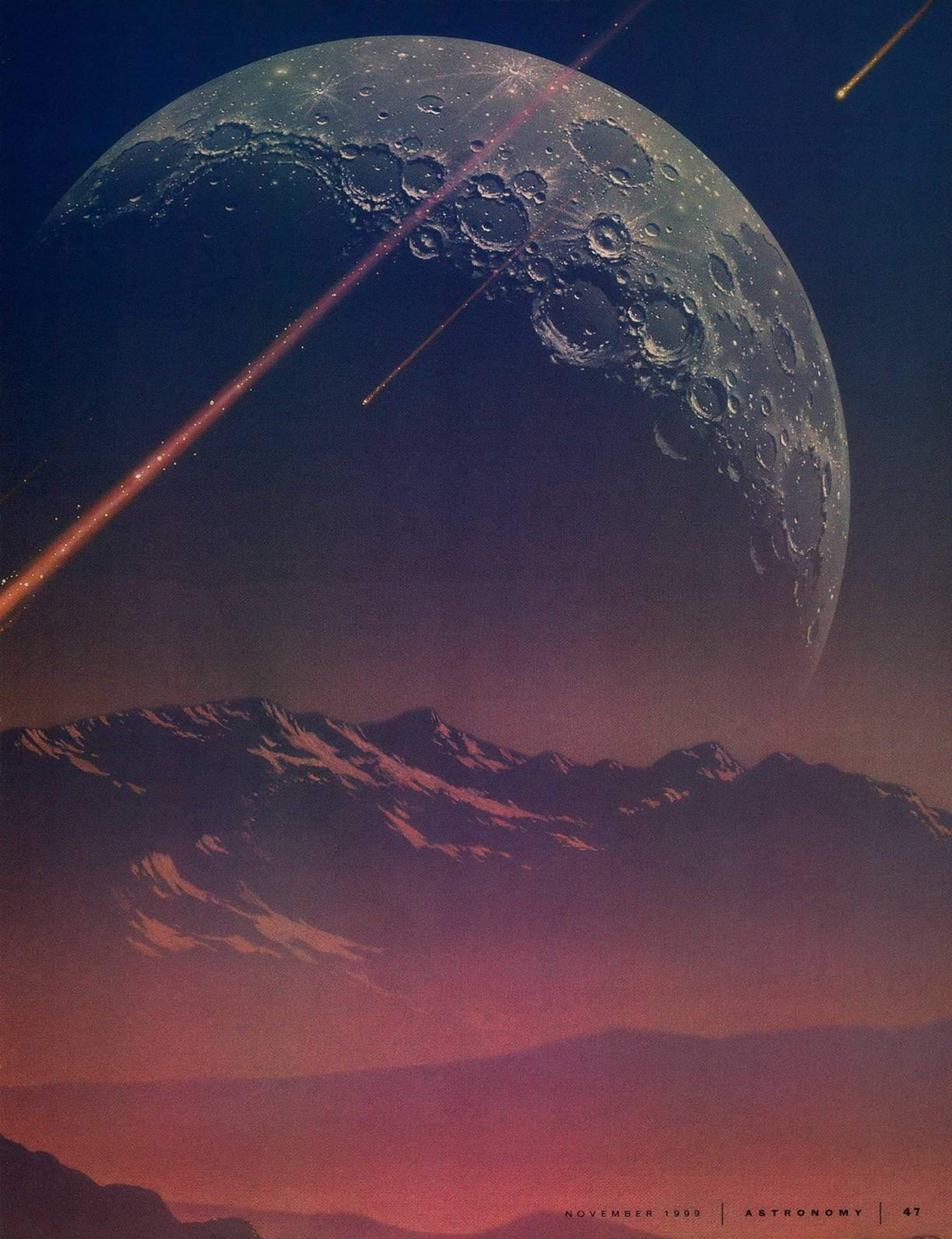
Keay Davidson is the science reporter for the San Francisco Examiner *and has written feature articles for* National Geographic *and* New Scientist. *He also coauthored the acclaimed book* Wrinkles in Time *with cosmologist George Smoot.*

When Disaster Strikes

Joe Tucciarone

If you think we live in a quiet corner of the galaxy, far from any major threats, think about comets and gamma-ray bursts.

by Robert Zimmerman



In 1966, science-fiction writer Larry Niven wrote a classic short story, describing how a spaceman making the first journey to the center of the Milky Way discovered that the galaxy's core had exploded 30,000 years earlier. A chain reaction of supernova blasts had ignited every star, and the wave of radiation from this eruption was flying outward at the speed of light.

"In 20,000 years a flood of radiation will wash over [Earth]," mused Niven's fictional astronaut. "Thirty thousand light-years might seem a long, safe distance, but it isn't, not with this big of an explosion. The Core explosion will make this galaxy uninhabitable to any known form of life."

Though Niven's description seems quaint to anyone familiar with modern astronomical research, no one should criticize him for this. When he wrote his short story in 1966, it was before the advent of today's orbiting gamma-ray, x-ray, infrared, optical, and ultraviolet telescopes. The up-close survey of our solar system had just commenced, with only one spacecraft, Mariner 4, returning pictures of only one world, Mars. No one then knew what really lurked in the depths of space beyond the comfy atmosphere of Earth.

Nonetheless, Niven was right. The starry sky is not the peaceful and enchanting blanket it seems on quiet summer nights in the country. There is danger out there, and even distances of many thousands of light-years are not enough to protect us. Like Niven's imaginary astronaut, we are discovering a copious menu of objects that can reach out from great distances and smack us. From supernovae to gamma-ray bursts to comets, the sky harbors dangers that turn the universe into a violent and dangerous place.

Let us take a short tour of these assorted dangers. What we find not only might provide explanations for much of Earth's fossil record, but it also might predict the fate of our planet billions of years into the future.

Dangerous Debris

Of all threats from space, asteroids and comets are surely the most well known. Since 1980, when Luis Alvarez, Walter Alvarez, Frank Asaro, and Helen V. Michel proposed that a giant meteorite impact had caused the extinction of the dinosaurs 65 million years ago, such impacts have become fodder for movies, TV shows, plays, and talk shows. The subject's popularity was enhanced when Comet Shoemaker-Levy 9 smashed into Jupiter in July 1994, producing easily visible impact sites surrounded by rings of clouds expanding at supersonic speeds.

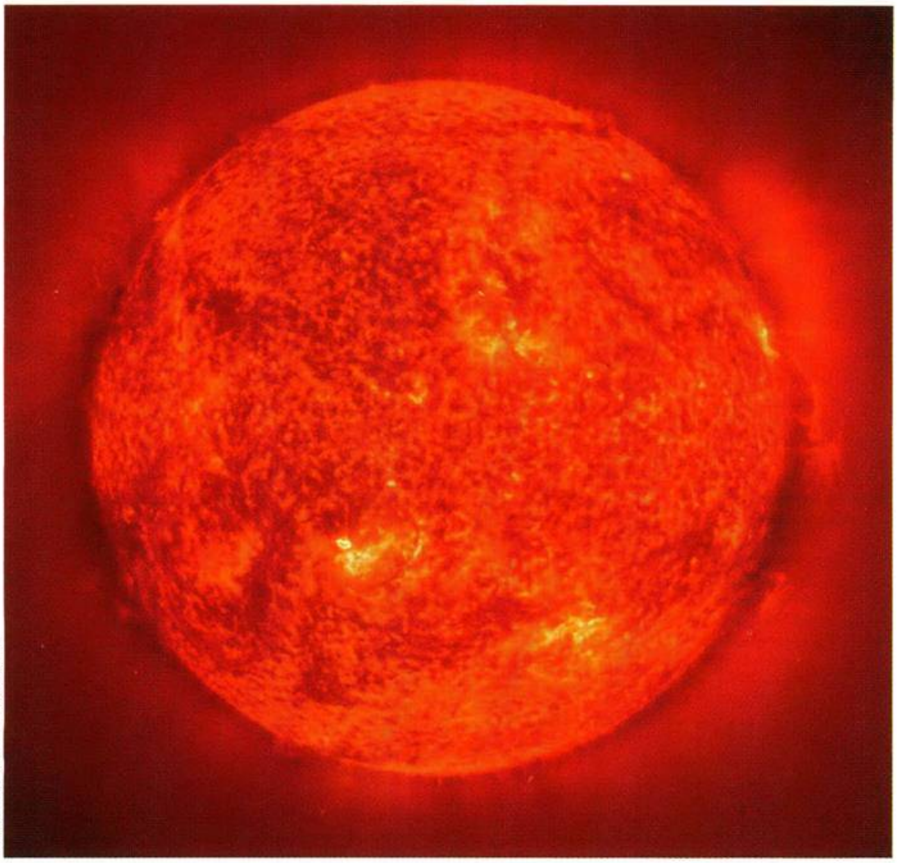
The destructive force of an asteroid is daunting. A single bolide six miles across (about the size of the asteroid that killed the dinosaurs 65 million years ago) would hit Earth with the force of about 100 million megatons of TNT, about 10,000 times greater than the world's entire arsenal of nuclear weapons. If the object hit an ocean it would produce tsunamis hundreds of feet high. The debris from such an impact would carpet hundreds of miles of surrounding terrain with house-sized boulders, while saturating the atmosphere with dust for years.

Fortunately, the threat from asteroids can be predicted. Astronomers have estimated that about 2,000 asteroids more than a kilometer in diameter cross Earth's orbit. Although only about 10 percent of these have been discovered, a concerted effort could effectively map the nearby threat, giving humanity warning of any future impact. Three different projects, one run jointly by NASA and the Air Force and the other two under the supervision of the Lunar and Planetary Laboratory of the University of Arizona, today scour the skies for these Earth-crossing asteroids, finding a handful of new objects each month.

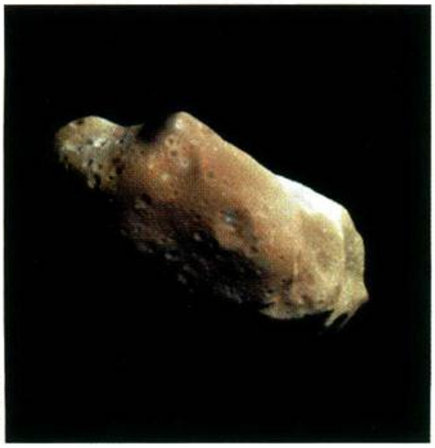
The danger from comet impacts, however, is less predictable. Most comets come from the Oort Cloud, orbiting the sun at about half a light-year's distance. Directly observing these objects is currently impossible, so Jay A. Frogel and Andrew Gould of Ohio State University recently found another way. The two astronomers surveyed the positions and motions of most nearby stars, theorizing that if one had recently passed close to the sun it would have disturbed the Oort Cloud, triggering a downpour of comets earthward. Since such a deluge would take several hundred thousand years to reach the inner solar system, Frogel and Gould figured

People in Medieval Europe viewed comets as harbingers of disaster. Little did they know how close they were to the truth.

Jerry Schad



NASA/ESA/ SOHO EIT Consortium



NASA/JPL

The sun, seen above in a SOHO image, is not the constant star astronomers once believed. Asteroids the size of 35-mile-wide Ida (left) would exterminate humanity if they hit Earth.

a recent close approach would predict an impending cloudburst.

Fortunately for our immediate descendants, the scientists discovered that in the last several million years no star has passed close enough to disturb the Oort Cloud. Our distant descendants, however, will have to contend with one star (Gliese 710) that in 1.3 million years will pass close enough to turn the present drizzle of comets into a thunderstorm.

Earth's Shining Beacon

Besides asteroids and comets, there are many other astronomical threats that are less well known but equally worrisome. Did you know, for example, that our sun, that constant, never-changing daily beacon in the sky, is actually a variable star? Since 1978, when the Nimbus 7 satellite went into orbit, astronomers have been tracking the sun's total luminosity and have found that it varies by about 0.1 percent over the 11-year solar cycle, with its ultraviolet radiation fluctuating by as much as 50 percent.

Nor is this light rhythm the limit of the sun's oscillations. By studying the sun's magnetic cycles over the last 10,000 years, John L. Jirikowic and Paul E. Damon of the University of Arizona found a number of long-term solar rhythms, including three separate cycles of approximately 88, 212, and 2,130 years. As these cycles interweave, they either magnify or nullify each other, thereby changing the sun's total luminosity and in turn Earth's climate. For example, a significant period of high solar magnetic activity around A.D. 1200 links directly to a long term 13th-century heat wave on Earth, during which serious droughts destroyed many of the American Indian cliff-dwelling cultures of the southwest. Conversely, during the period from 1645 to 1715, the sun produced few sunspots and was magnetically quiet, and Earth went into what is today called the "Little Ice Age." Across this 500 year period, Earth's average global temperature rose and fell by as much as 3° F.

Over even longer time scales, scientists fear that these variations are mild for a star like the sun. For the last few years, astronomers Sallie Baliunas, Mark Giampapa, and Richard Radick have used the WIYN Telescope at Kitt Peak in Arizona to study 75 sunlike stars. The astronomers picked stars that were virtually identical to the sun in age, temperature, mass, and chemical makeup. Between 10 and 20 percent of these stars were significantly less active than our sun, exhibiting even less sunspot or magnetic activity than recorded during the Little Ice Age of the 1600s. And between 30 and 50 percent were one-third more active than the sun during its solar maximum. "More than half the time other sunlike stars are either more or less active than the sun," notes Giampapa.

Unless the sun is a very unusual star, it should spend approximately half its time either significantly colder or significantly hotter than indicated by the historical human record. As Gary Rottman of the University of Colorado in Boulder recently noted, "The more I work in this area, the more it seems phenomenal to me that the sun is as stable as it is." And any increased fluctuations would certainly bring mayhem to Earth's ecological balance.

Threats from Farther Away

If the sun is more constant than these other stars might lead us to believe, would our worries be any less?

Hardly. The sun still travels through a complex and violent galaxy, whose gaseous and stellar terrain can directly affect Earth's environment. A recent study by Priscilla Frisch of the University of Chicago has shown that for the last few million years, our solar system has been strolling peaceably through an extremely empty and quiet part of the galaxy. Sometime in the last 250,000 years, a wave of material rolled past us and, today, a second wave rumbles by. Both waves are thought to be expanding shock waves blasted out from a dense region of molecular clouds during a period of star formation several million years ago. Both clouds have exerted pressure on the sun's heliosphere, the region dominated by the sun's magnetic field that helps to protect us, but neither has significantly compressed it.

In about 50,000 years, however, the sun will enter a very dense region called the Aquila Rift. Here interstellar space is packed with molecular clouds, which could directly affect Earth and the sun. The pressure on the heliosphere will squeeze it so that Earth's orbit will be outside its boundaries, exposing Earth's atmosphere and magnetic field directly to the interstellar medium. "If the interstellar cloud is dense enough, the interstellar medium becomes the interplanetary medium," notes Frisch.

Though scientists are not yet sure of the exact consequences of such an event, they do know that Earth's climate and atmosphere would feel a direct impact. Without the heliosphere to protect it, Earth's atmospheric chemistry would change, its magnetic field would be warped, the electrical connection between the magnetic fields of the sun and Earth would be disrupted, and increased amounts of interstellar dust would be dumped into the atmosphere. Any or all of these changes would disturb Earth's ecological balance, likely destroying numerous species.

In ferreting out the effect of the sun's earlier passages through denser galactic regions, Erik Leitch and Gautam Vasisht of Caltech compared the timescale of previous mass extinctions during the past half billion years with the sun's orbit through the Milky Way. They found an almost certain correlation between the last three mass extinctions and the sun's journeys through the galaxy's Sagittarius-Carina and Scutum-Crux spiral arms. Leitch notes that "We will be smack in the middle of the next spiral arm in something like 140 million years."

When the solar system enters these galactic urban areas (a journey that lasts approximately 60 million years), it flirts with dangers more violent than simply dense clouds. With stars packed more closely together, the chance of a close approach to the Oort Cloud grows significantly greater, thereby potentially unleashing a storm of comets on Earth.

Stellar Explosions

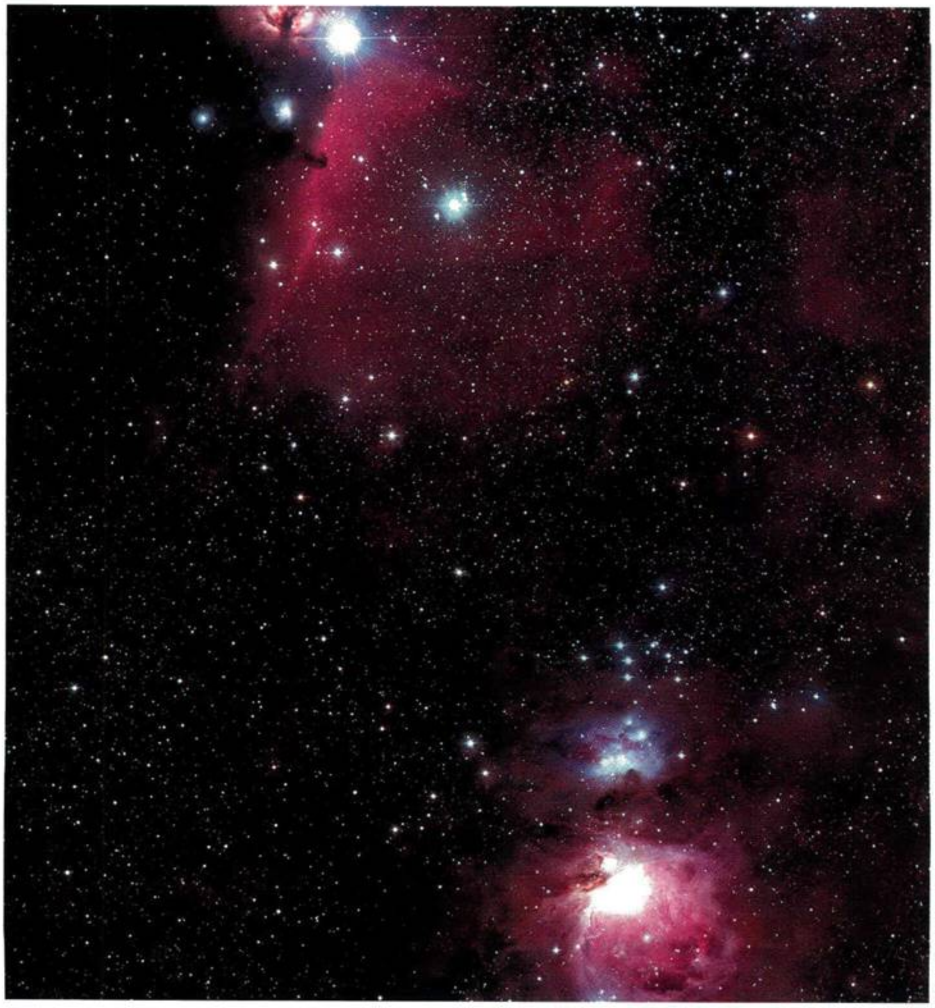
Even more worrisome is the increased possibility that a supernova will explode while the sun is nearby. "During the sun's passage through a spiral arm, you've essentially got a 50-50 chance of being hit by a supernova," Leitch says. Had we been as close as 35 light-years to Supernova 1987A, the wave of radiation would have stripped Earth's ozone layer for a period ranging from decades to more than a century. This loss would have left the surface exposed to the sun's ultraviolet radiation — at levels high enough to damage plant life and cause mass extinctions. Simultaneously, the gamma-ray and x-ray radiation would have caused a significant increase in atmospheric nitrogen and nitrogen dioxide, which absorb sunlight and thereby cause global cooling — by as much as 5° F.

In fact, there is evidence that the Vela supernova, which took place between 8,400 and 11,300 years ago at a distance of about 1,600 light-years, caused some environmental changes. G. Robert Brakenridge of the University of Arizona has found that at about the same time as the Vela supernova there was a drop in the number of species of oceanic plankton, which are highly vulnerable to increased ultraviolet light, as well as significant surges in organic soil deposits. The rainout of higher levels of atmospheric nitrogen would have helped feed such an increase.

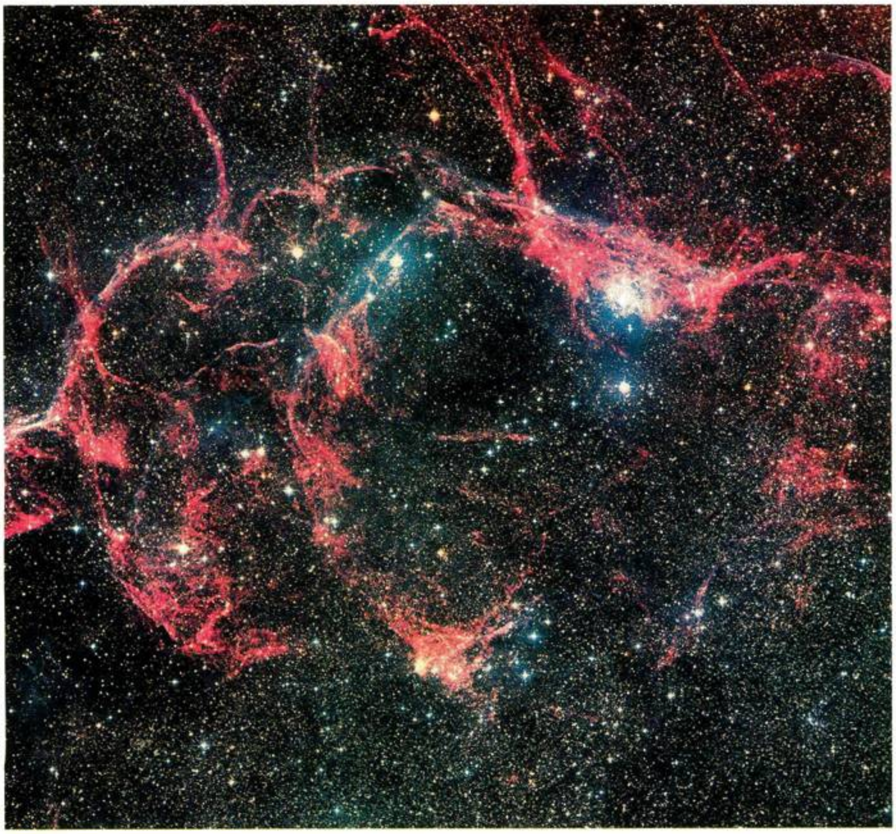
As the sun orbits the center of the galaxy, dangers are not only found inside spiral arms. Gamma-ray bursts, rare events within any galaxy but which occur about once a day throughout the universe, generate more energy in seconds than the sun will produce in its entire multibillion year life span.

Scientists today favor two theories to explain these powerful explosions. The first, proposed by Bohdan Paczynski of Princeton University in 1986, suggests that gamma-ray bursts are produced either from the merger of two neutron stars or the swallowing of a neutron

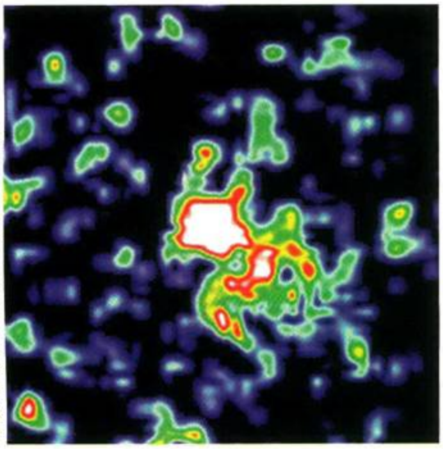
While molecular clouds such as the Horsehead and Orion nebulae are beautiful sights, we wouldn't want Earth to venture inside one.



Bill and Sally Fletcher



Anglo-Australian Telescope Board/Photography by David Malin



Kailash Sahu, Mario Livio (STScI), et al., and NASA

Interstellar space is occasionally rocked by titanic explosions that can affect life on Earth. A supernova in Vela (the remnant is above) coincided with a drop in species of plankton. A gamma-ray burst (left) could sterilize Earth's surface if it occurred within 3,500 light-years.

star by a black hole. The high-speed orbits of such massive objects cause the binary system to lose angular momentum. The two objects slowly spiral toward each other, eventually crashing together in a cataclysmic explosion.

The second theory links gamma-ray bursts to unusual supernovae, or what some astronomers call hypernovae or collapsars. When an extremely massive star collapses and explodes at the end of its life, scientists theorize that the blast wave is sometimes focused into bipolar jets. The blast's energy is therefore concentrated, and any object in its crosshairs experiences an explosion 100 times more powerful than an ordinary supernova. In both the neutron star and stellar explosion theories, the energy bombarding Earth is almost the same.

Steve Thorsett of Princeton University has calculated the consequences of a neutron star merger within 3,500 light-years. The blast would bathe Earth in the equivalent of 300,000 megatons of TNT, 30 times the world's nuclear weaponry, with the gamma-ray and x-ray radiation stripping Earth of its ozone layer. Arnon Dar, Ari Laor, and Nir Shaviv of the Israel Institute of Technology have also shown that the cosmic rays deposited by such a blast would exceed the radiation striking Earth over 100,000 years, making Earth's atmosphere and surface radioactive. They estimate that half the human population would die within 30 days. "In Milky Way-like galaxies," they write, such explosions "destroy advanced life on every Earthlike planet on average every ten million years."

While scientists can't predict with any precision which nearby stars will go supernova, the merger of neutron star binaries is as predictable as a solar eclipse. Three such binary systems have been discovered and one, PSR B1534+12, sits about 3,500 light-years away and will coalesce in a billion years. Unlike supernovae, which are found mostly in the galaxy's spiral arms, neutron star binaries are very old systems, so they have had time to redistribute themselves throughout the galaxy. In 1991, E. S. Phinney at Caltech estimated that about 250 neutron star binary systems should exist in the Milky Way, and about three neutron star mergers should take place every 100,000 to a million years.

Despite the danger posed by gamma-ray bursts, supernovae are still a greater cause for concern. "There are about a million supernovae in the galaxy for each gamma-ray burst, so the probability of harm being done to us by a supernova is much higher than the probability that a gamma-ray burst may harm us," says Paczynski. Either of these events, gamma-ray bursts or nearby supernovae, might explain the Permian-Triassic mass extinction 250 million years ago, when the sun was traversing the Scutum-Crux spiral arm. Unlike the mass extinction 65 million years ago, no trace of a meteorite impact has been found for this earlier event, and so its cause remains unknown.

If ET Phones Home

And finally, we mustn't forget the millions of bug-eyed aliens lurking throughout the universe, all desirous of Earth and all planning to invade our hapless planet in mere weeks.

Most scientists today consider the possibility of extraterrestrial life a near certainty. Unlike most of the violent phenomena described above, however, alien creatures are *not* predictable. We will never know when we will find them (or they find us) and cannot forecast the repercussions from that contact.

When first contact happens, the best we will be able to do is embrace the experience, recognizing that the change will likely make us better. If we instead shirk the unknown, the consequences could be as destructive as a supernova igniting mere light-years away.

Robert Zimmerman's book Genesis: The Story of Apollo 8 *is about the first manned flight to the moon. His next book,* The Chronological Encyclopedia of Discoveries in Space, *will appear in January 2000.*

The Universe According to Arp

Odd-shaped galaxies stimulate odd theories about the evolution of our universe.

Text by Kelly Kizer Whitt and Photos by David Healy

Undoubtedly you've heard the saying "Nobody's perfect." That maxim could also apply to galaxies. While every galaxy, even spirals and ellipticals, has its own distinguishing characteristics, some have more idiosyncrasies than others.

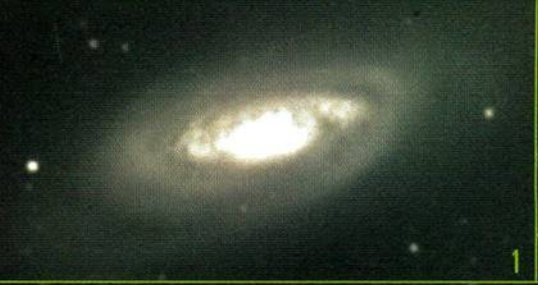
Halton C. Arp, an astronomer at the Max Planck Institute for Physics and Astrophysics, has been an observer of peculiar galaxies for over four decades. A graduate of Harvard and Caltech, Arp progressed to a postdoctoral position as an assistant to Edwin Hubble, the man whose research uncovered the nature of galaxies and who used redshifts to show that the universe was expanding. Later, Arp worked at Mount Wilson and Palomar Mountain observatories, using their telescopes to study unusual galaxies. Arp believed that by learning more about the strangest galaxies in the universe, astronomers could gain insight into how galaxies form and why they acquire their distinctive shapes.

In 1963, Arp published the *Atlas of Peculiar Galaxies*, a compilation of 338 of the most bizarre-looking galaxies seen from the Northern Hemisphere. (Eventually, in 1987, he came out with two volumes on peculiar southern galaxies.) The same year that Arp finished his first atlas, Maarten Schmidt discovered quasars. Quasars are remarkable because of their high redshifts, indicating that they are extremely far away. Arp decided to study quasars in an effort to see if there was a pattern to their distribution in the sky. He found that quasars tend to be seen near peculiar galaxies, rather than equally distributed across the vastness of space. The question arises that if quasars are really much more distant than the peculiar galaxies, then why, in certain instances, do they seem to occupy some of the same regions in space?

Arp's answer to that question was that redshifts are not due to recessional velocity but to some other, unknown effect. Contrary to the view of almost all astronomers today, Arp maintains that some peculiar galaxies and quasars are linked and that quasars are probably even ejected from the centers of galaxies; thus, redshifts do not measure distance; the universe cannot reliably be said to be expanding; and the big bang theory is suspect at best. This controversial upheaval of cosmology is taken seriously in few, if any, academic circles. But Arp continues his work, publishing, in 1998, a book titled *Seeing Red*.

While Arp's cosmological work is anything but mainstream, his *Atlas of Peculiar Galaxies* is quite popular. The Astronomical League has organized an observing club for its members devoted to Arp's galactic oddities. They challenge participants to observe or photograph 100 of the 338 Arp galaxies to qualify for the club certificate. A majority of the galaxies have very dim magnitudes, between 12 and 18. A dark-sky site and a telescope of 12 inches or larger are needed to bag your 100. Even if you're not a member of the Astronomical League, you can enjoy some of the fascinating and misshapen galactic forms, either by glancing at the opposite page or getting out under the stars with your own telescope.

Opposite Page: 1 Arp 76 (M90), spiral galaxy with small, high surface brightness companions on arms; 2 Arp 6 (NGC 2537), spiral galaxy with low surface brightness; 3 Arp 263 (NGC 3239), galaxy with irregular clumps; 4 Arp 214 (NGC 3718), galaxy with irregularities, absorption, and resolution; 5 Arp 112 (NGC 7805), elliptical galaxy repelling spiral arms; 6 Arp 120 (NGC 4438), elliptical galaxy close to and perturbing spiral arms; 7 Arp 243 (NGC 2623), galaxy with appearance of fission; 8 Arp 140 (NGC 275), material emanating from an elliptical galaxy; 9 Arp 28 (NGC 7678), galaxy with one heavy arm; 10 Arp 271 (NGC 5426), double galaxy with connected arms; 11 Arp 157 (NGC 520), disturbed galaxy with interior absorption; 12 Arp 202 (NGC 2719), galaxy with material ejected from nucleus; 13 Arp 23 (NGC 4618), one-armed spiral galaxy; 14 Arp 167 (NGC 2672), galaxy with diffuse counter-tails; 15 Arp 217 (NGC 3310), galaxy with adjacent loops; 16 Arp 16 (M66), spiral galaxy with detached segments.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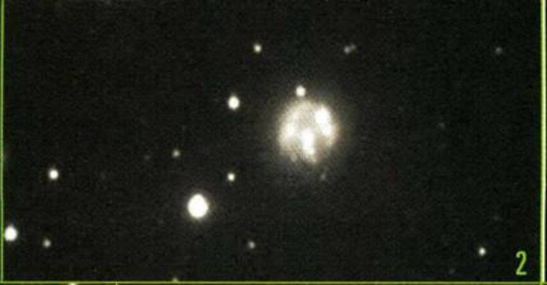
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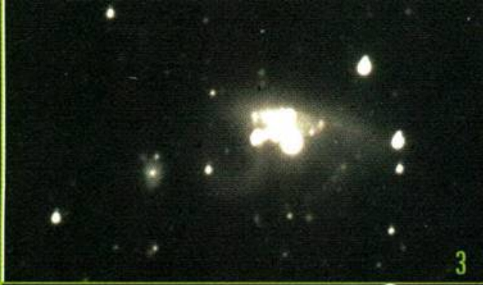
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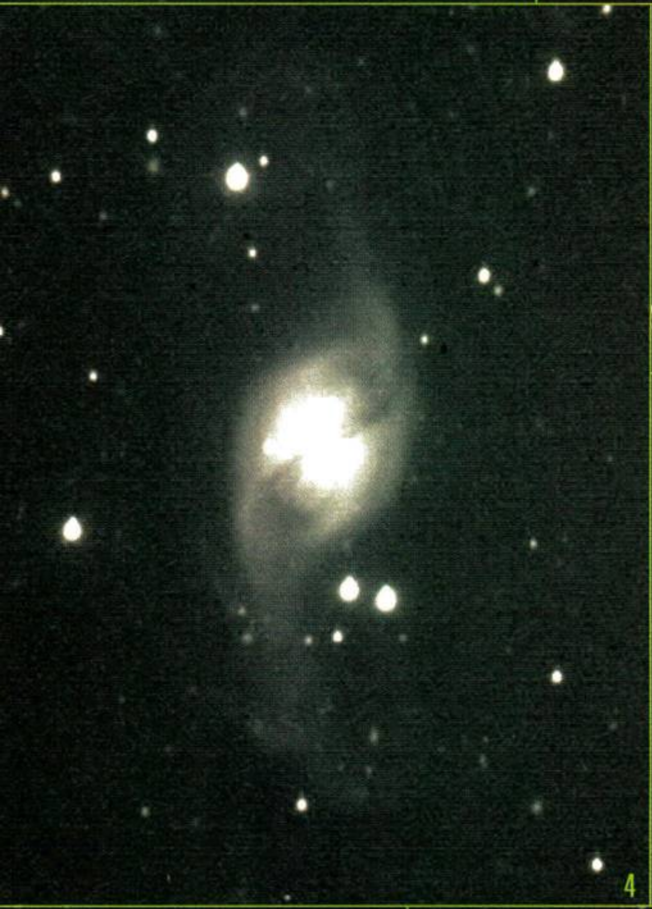
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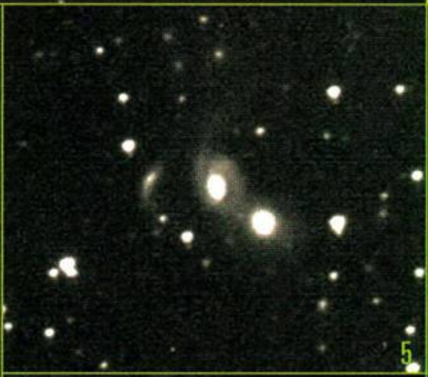
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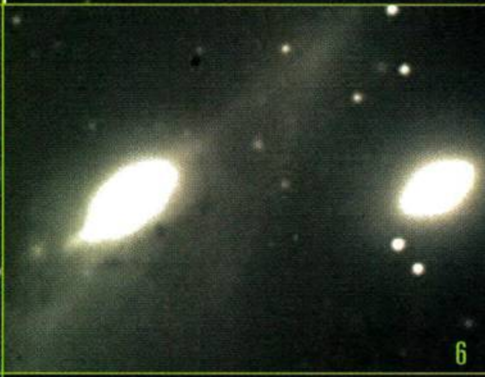
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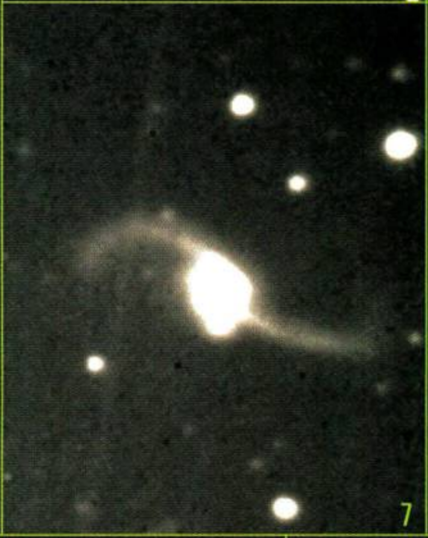
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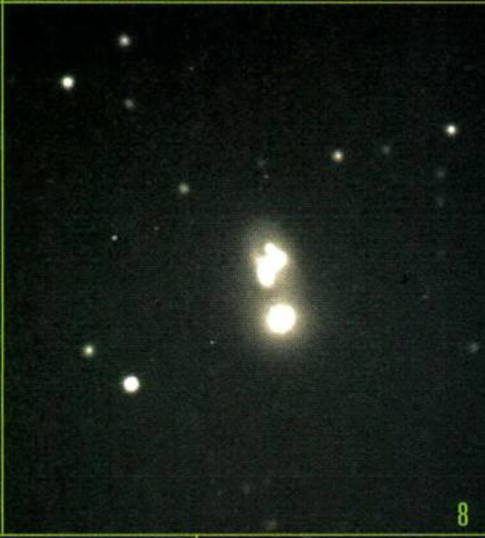
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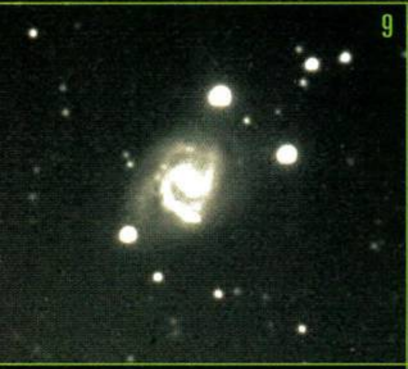
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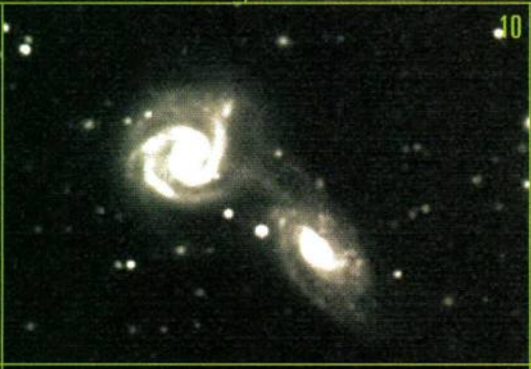
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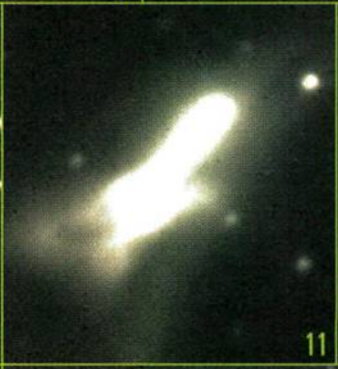
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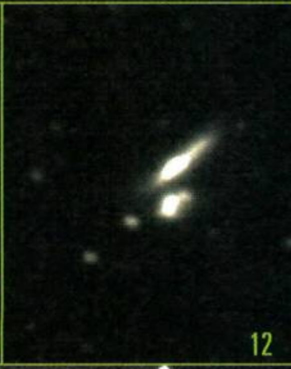
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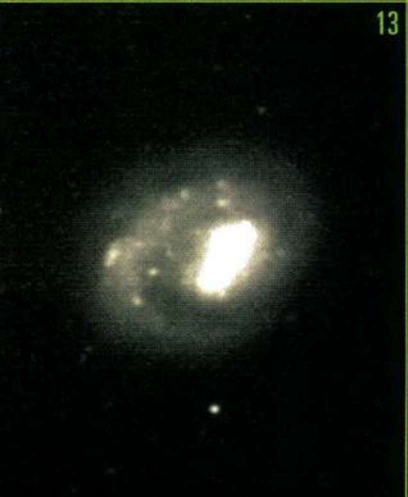
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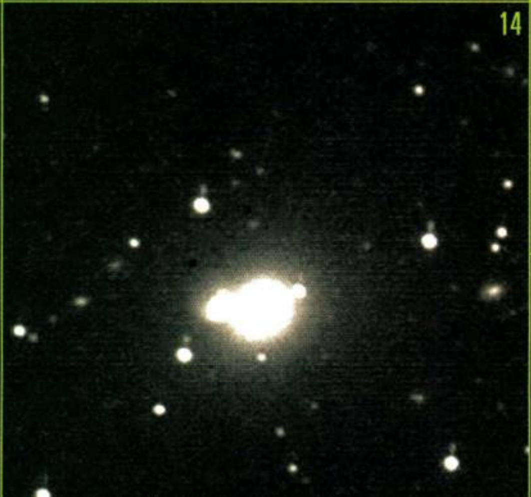
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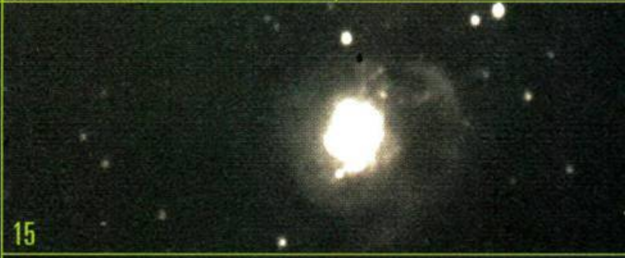
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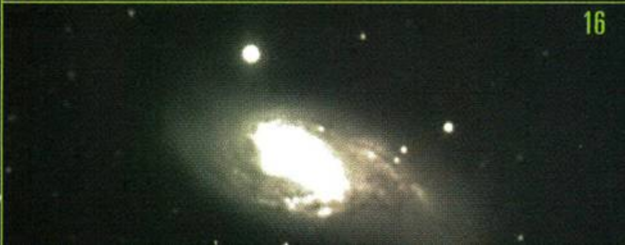
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Rescuing Hubble

This October, four spacewalking astronauts will prepare the Hubble Space Telescope for its next decade of observations.

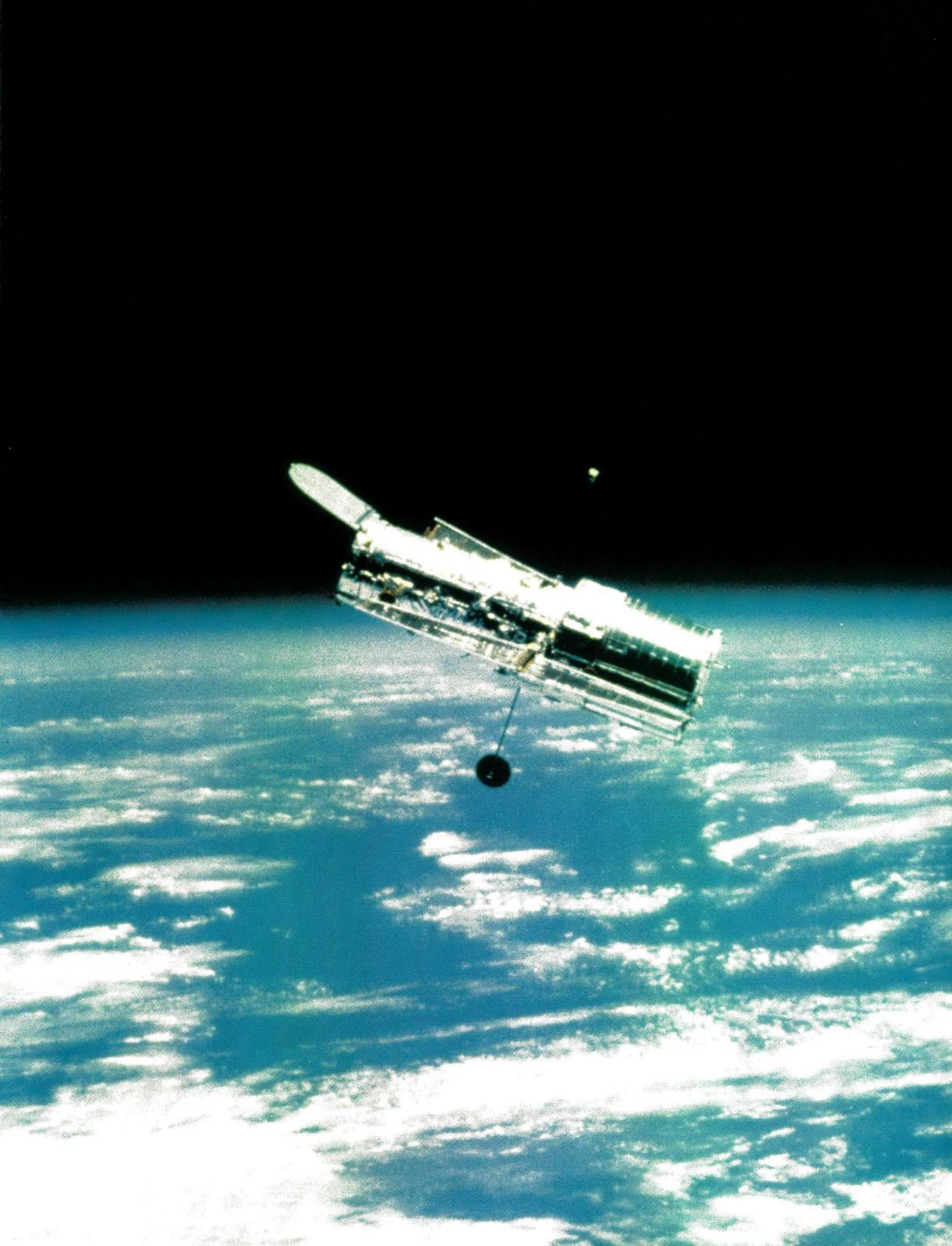
by Robert Naeye

Like a fine wine, the Hubble Space Telescope keeps getting better with age. How can this be, you might be wondering, when the telescope is constantly exposed to the debilitating effects of 400° F (220° C) temperature swings, high doses of radiation, and a constant rain of micrometeorites?

The answer is simple. Hubble was specifically designed to be serviced by space shuttle astronauts, who breathed new life into the telescope during two previous 350-mile-high house calls. In December 1993, four spacewalking astronauts brought the telescope back from the brink of disaster when they installed optics to correct for Hubble's flawed primary mirror. In February 1997, astronauts installed two new scientific instruments: the infrared camera NICMOS and an imaging spectrograph called STIS.

If all goes according to schedule, the next Hubble servicing mission will launch on October 14, 1999. On that day, an international seven-man crew will rocket into space aboard the space shuttle Discovery. Four spacewalkers, three of whom are astrophysicists, will replace the telescope's failing gyroscopes, install a new computer, and perform several other repairs and upgrades. This third servicing mission won't

NASA



involve radical surgery, but it will make the telescope more reliable while paving the way for new science instruments in the future (see "The Future of Hubble," page 58).

A Rescue Mission

The October 1999 servicing mission was moved up eight months by necessity, not choice. NASA had planned an ambitious Servicing Mission 3 for June 2000, with six scheduled space walks (known as EVAs in NASA-speak, for Extra-Vehicular Activities). Besides inserting new gyros and the new computer, the astronauts would install the state-of-the-art Advanced Camera for Surveys, a refrigerator to revive the failed NICMOS camera, and powerful new solar arrays. For the astronauts, this was to be by far the most challenging of all the Hubble servicing missions.

But NASA's plans unraveled earlier this year. Two of the telescope's six gyros had already failed, and on January 24, 1999, a third gyro began to hiccup. Hubble can't point accurately enough at targets to do science unless three or more gyros are functioning properly. If one more failed, Hubble would be sitting idly in space, wasting tens of millions of taxpayer dollars.

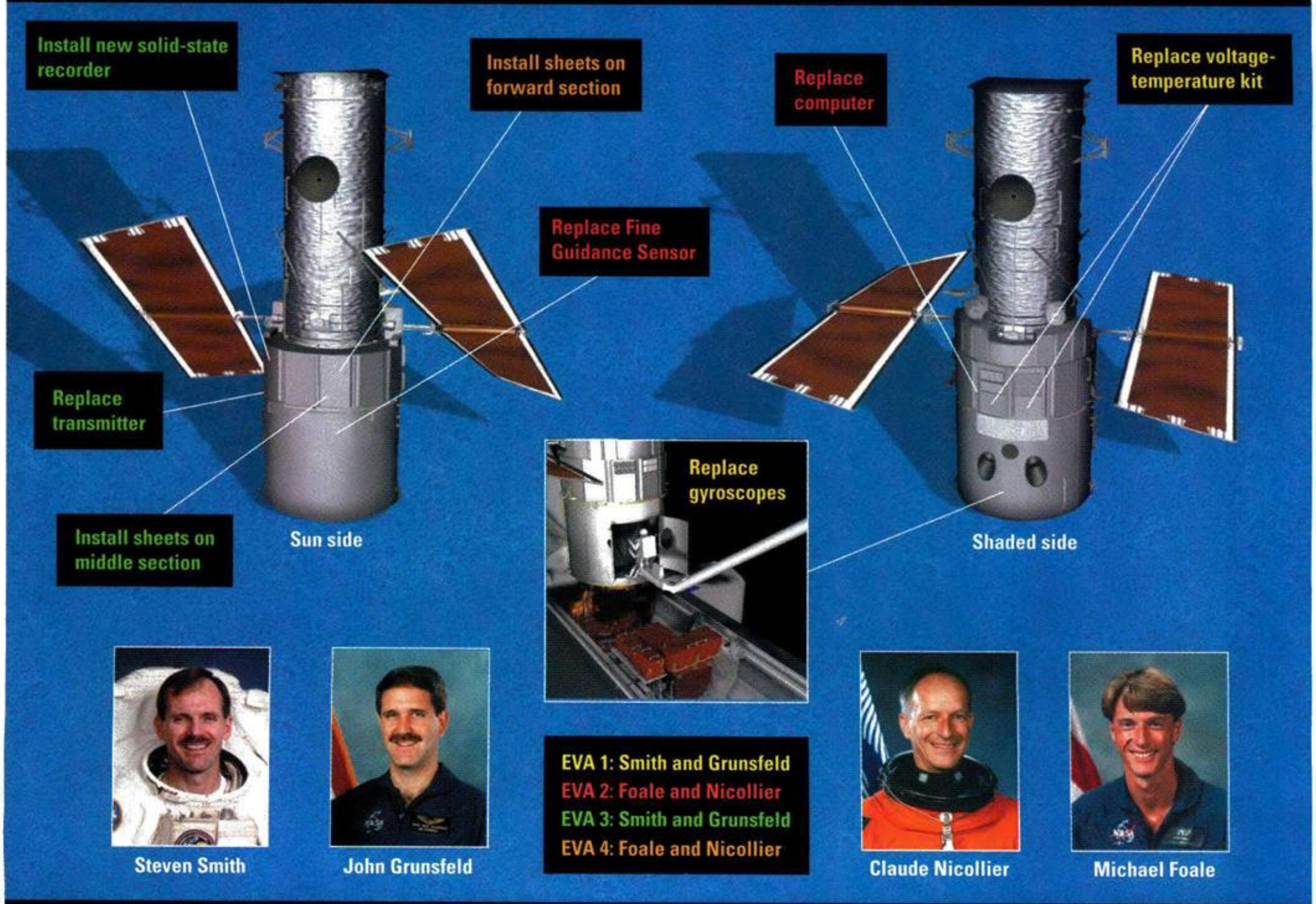
"When the third gyro failed, we estimated odds of between 1-in-3 and 1-in-2 that Hubble would lose another gyro prior to June 2000," says Hubble project director John H. Campbell of NASA's Goddard Space Flight Center. "There was a 10 to 20 percent probability that the next gyro failure would occur as early as June or July 1999, one year prior to the scheduled launch of Servicing Mission 3. The possibility of a one-year downtime was unacceptable."

On February 19, Campbell's office asked NASA headquarters if it could divide Servicing Mission 3 in two and schedule a shuttle mission as soon as possible to replace the gyros. On March 10, NASA complied: Servicing Mission 3 was split into missions 3A and 3B. Because the gyros needed to be replaced as soon as possible, and the Advanced Camera, NICMOS refrigerator, and solar arrays wouldn't be ready for nearly a year, the 3A mission was slated for October 1999, while the more ambitious 3B mission was tentatively scheduled for June 2001 (Campbell says there's a good chance it will be moved up to December 2000).

The EVA Ballet

Servicing Mission 3A, designated STS-103 by the shuttle program, has a veteran crew of seven astronauts who collectively have 18 prior space shuttle missions to their credit. Former U.S. Air Force pilot Curtis Brown, Jr. will command the mission. Brown, who will do the bulk of the flying, was also the commander of John Glenn's 1998 shuttle flight. Scott Kelly, who flew F-14s and F-18s for the U.S. Navy before joining the astronaut corps, will serve as pilot; he is the only rookie on STS-103. European Space Agency (ESA) astronaut

HUBBLE HOUSE CALL


Install new solid-state recorder
Install sheets on forward section
Replace computer
Replace voltage-temperature kit
Replace Fine Guidance Sensor
Replace transmitter
Replace gyroscopes
Install sheets on middle section
Sun side
Shaded side
Steven Smith
John Grunsfeld
Claude Nicollier
Michael Foale

EVA 1: Smith and Grunsfeld
EVA 2: Foale and Nicollier
EVA 3: Smith and Grunsfeld
EVA 4: Foale and Nicollier

To learn more about this mission and to read biographies of the crew, visit: www.ksc.nasa.gov/shuttle/missions/sts-103/mission-sts-103.html

NASA/*Astronomy*: Terri Field

From left to right, the crew of STS-103 Hubble Servicing Mission 3A: Michael Foale, Claude Nicollier, Scott Kelly, Curtis Brown, Jean-François Clervoy, John Grunsfeld, and Steven Smith. NASA/JSC

Jean-François Clervoy of France will operate the shuttle's Canadian-built robotic arm.

A pair of two-man teams will do the EVAs. Steven Smith, a former electrical engineer who performed three space walks during the February 1997 servicing mission, will be paired with John Grunsfeld, an astrophysicist who studies high-energy objects such as x-ray pulsars and black holes. British native Michael Foale, who spent 134 days on the Russian space station Mir in 1997, will do EVAs with ESA astronaut Claude Nicollier of Switzerland. Nicollier operated the robotic arm during the December 1993 servicing mission. Like Grunsfeld, Foale and Nicollier both have advanced degrees in astrophysics.

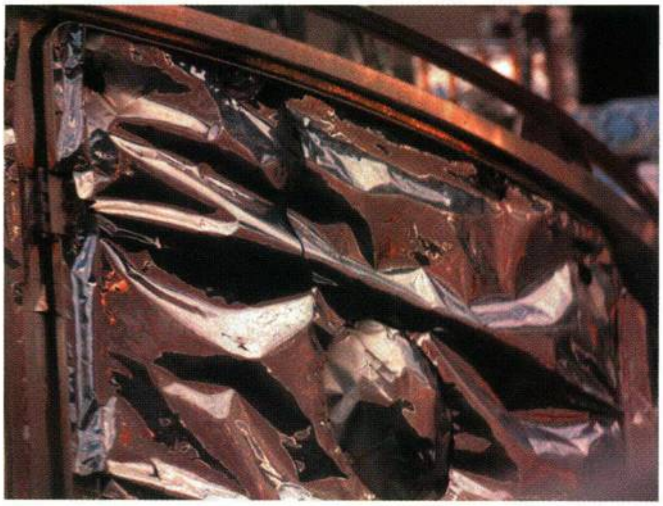
Two days after launch, Brown will deftly maneuver Discovery into position to rendezvous with Hubble. "The main thing we worry about is the fragile solar arrays," says Brown. "We're flying an orbiter that weighs 230,000 pounds, and we're very precisely maneuvering within tolerances of inches as we slowly move into position so that the robotic arm can grab the telescope."

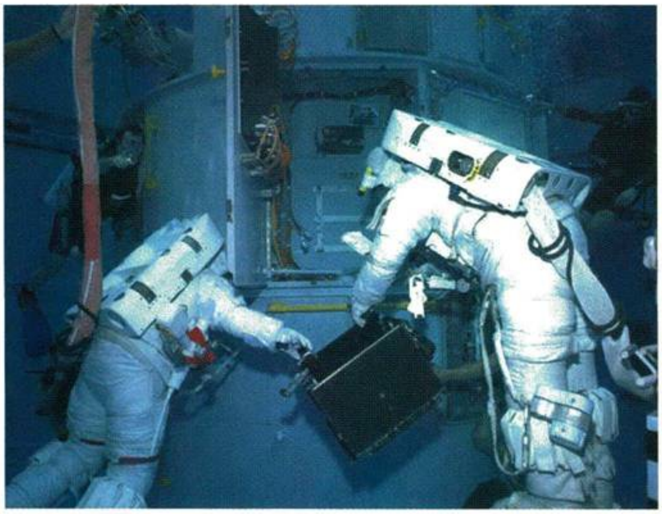
On the third day of the 10-day mission, Smith and Grunsfeld will venture outside the shuttle to perform the first of four 6-hour EVAs. The two astronauts will install a kit that protects the batteries from overcharging, but their main chore will be to replace all six gyros. As Smith says, "It's the single most important thing we're doing."

Because NASA anticipated that the gyros would eventually fail, they were designed to be replaced. But this EVA is hardly a leisurely afternoon stroll in the park. "It means going right into the bowels of the telescope, right into one of the most sensitive regions," says Grunsfeld. Smith and Grunsfeld will take turns guiding each other into passageways that are just barely wide enough to accommodate an astronaut in his space suit. Standing virtually motionless like statues for three half-hour shifts, they will have to disconnect three boxes containing the old gyros and replace them with three new boxes. "We're told we can't touch anything, except for the box we're replacing," says Grunsfeld. "You have to remember that when you take a box out, it might be a $5-million or $10-million box that you're holding, and that you're working inches away from a $5-billion astronomical resource."

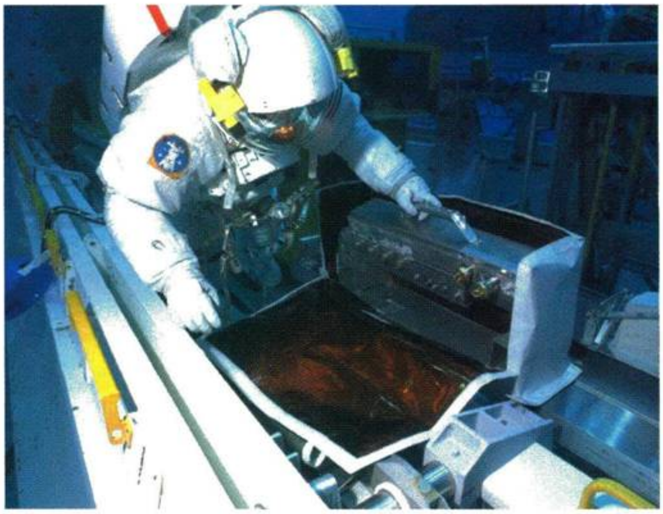
The next day, it's Foale and Nicollier's turn. They will replace Hubble's "ancient" computer, which is based on

The skin on Hubble's sunward side is cracking and peeling. The astronauts will place large metal "Band-Aids" over the skin. NASA/JSC





Astronauts Claude Nicollier and Michael Foale float in a giant water tank as they simulate changing out the Advanced Computer. NASA/JSC



Steven Smith removes the Solar Array 3 Diode box from its protective enclosure in the same practice tank. NASA/JSC

1970s technology, with a computer based on early 1990s technology (it has a 486-class processor). The new computer will pay immediate dividends by reducing operating costs. Foale and Nicollier will also replace one of Hubble's three onboard Fine Guidance Sensors that allow the telescope to be pointed precisely at an astronomical target. The new sensor was brought down to Earth during the previous servicing mission and then refurbished; the sensor being taken down on this mission will be refurbished and brought back up on a later mission.

During the third EVA, Smith and Grunsfeld will install a new transmitter to replace one of the two that failed last year. NASA didn't anticipate such a failure, so the transmitter wasn't designed to be replaced. To remove the old unit, Grunsfeld will use common hand tools to take out eight tiny bolts and washers and three cables with subminiature connections — a difficult task with the large, balky gloves of his space suit. Grunsfeld will have to make sure he collects each bolt and washer, so they don't float around inside the telescope. "Some people have trouble replacing these with bare fingers. It's a challenging task — it's very hand-intensive and tiring — but I think we've worked out a good system so I'm confident it will go okay," says Grunsfeld.

Smith and Grunsfeld will also replace an old-fashioned reel-to-reel tape recorder with a new solid-state data recorder. The new recorder has 10 times more data storage capacity, which will be essential once the Advanced Camera is installed on the 3B mission and two new science instruments (the Wide Field Camera 3 and the Cosmic Origins Spectrograph) are installed on Servicing Mission 4 in 2003. In addition, Smith and Grunsfeld will attach stainless steel "cookie sheets" to parts of Hubble's skin in the middle section that have been scorched by sunlight, causing cracking and peeling.

On the fourth and final EVA, Foale and Nicollier will affix rolls of wallpaper-like sheets to the forward sections of Hubble's sunburned skin near the light shield. Foale and Nicollier will stretch the limit of the robotic arm to reach the top of the telescope, providing an exceptional view of Hubble, Discovery, and Earth.

Just because one pair of astronauts is outside doing an EVA doesn't mean the other pair gets to take the day off. The

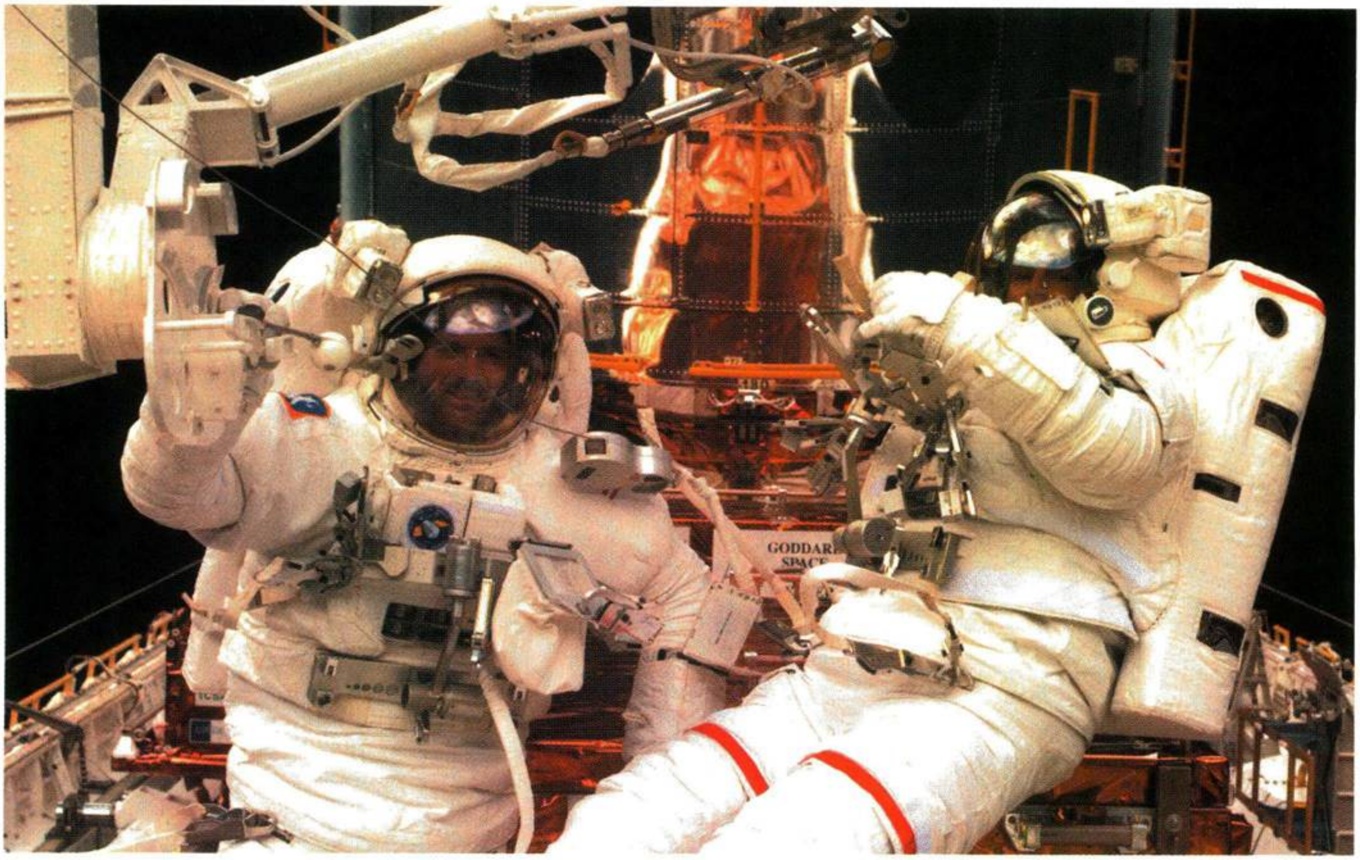
The Future of Hubble

If all goes well with the 3A mission, Servicing Mission 3B will install the $50-million Advanced Camera for Surveys (ACS), which will have roughly twice the resolution and field of view of Hubble's current visible light camera, the Wide Field/Planetary Camera 2 (WFPC2). ACS will provide roughly 10 times more information per picture than WFPC2.

Servicing Mission 4 is currently scheduled for 2003. Besides replacing the gyros again, astronauts will install two powerful new instruments that will shed light on the evolution of the universe, the Wide Field Camera 3 and the Cosmic Origins Spectrograph. "The way we create new science is [often] with new instruments," says Steven Beckwith, the new director of the Space Telescope Science Institute. "Every time you put a new set of instruments on an old telescope, you just rejuvenate it completely."

The ACS is scheduled to be installed in 2001. Johns Hopkins University

Under current plans, the Next Generation Space Telescope will be launched in 2007. Hubble will be decommissioned and possibly brought back to Earth in 2010, where it might eventually be put on display at the Smithsonian Institution. – *R.N.*



Steven Smith and Mark Lee work in Discovery's payload bay during the second Hubble servicing mission in February 1997. NASA/JSC

astronauts inside the shuttle run through the checklist, operate the robotic arm if Clervoy needs to take a break, and act as extra sets of eyes for the EVA crew. Says Smith, "The guy inside is basically the boss, he's totally in charge of what the guys do outside. He's got the checklist, he's got all the resources that the guys outside don't have. He is the one who conducts the ballet."

Mission of a Lifetime

The four spacewalkers have spent more than a year training for the mission. To simulate the weightlessness of outer space, they train on a mock-up of Hubble inside a 6-million-gallon water tank at NASA's Johnson Space Center in Houston. The training is grueling, sometimes involving 6-hour stints in the water for several days in a row. Astronauts generally practice 10 hours in the pool for each EVA hour, which translates to 120 hours underwater for every STS-103 spacewalker.

The water training is useful, but astronauts have to constantly remember that objects behave very differently in the weightlessness of space, where there is no water or gravity to restrain the motion of large objects. "It's positively training you in some ways and it's negatively training you in others," says retired NASA astronaut Story Musgrave, who performed three EVAs during the first Hubble servicing mission. "You can't turn gravity off. Every single second in the water you have to ask yourself what are the real lessons, because it's not going to be that way in space."

Despite the limitations, Smith says the water training prepared him extremely well for his EVAs during the second servicing mission. "The biggest surprise was that there were no surprises. It really felt like I had been there before, even though I had never seen the Hubble Space Telescope in my life. That's a pretty good indication of how accurate the training is."

Every astronaut who's done a space walk will tell you that it's an unforgettable thrill. But astronauts also know there is an element of danger. Musgrave says space is so quiet and serene that there's no sense of imminent danger, and in more than 30 years of American and Soviet space walks, there hasn't been a single injury. By just following common sense and performing the proper safety checks on the space suit, there's not much that can go wrong. But if a sand-sized meteorite slammed into an astronaut's suit at 30,000 miles an hour, it would cause a fatal depressurization. "Only a few inches of cloth separate you from a vacuum," says Grunsfeld. "You're in control of your destiny except for a couple of things, one of which is micrometeorites."

Despite the intensive training and risks, STS-103 will be the mission of a lifetime for the entire crew, particularly the astrophysicists. "To go up to Hubble is the Holy Grail of an astronomer as an astronaut," says Grunsfeld. "Being that close to the telescope is going to be incredible. The astronomical community should feel comfortable that we understand the significance of the telescope and how important it is that everything goes just perfectly." ◼

Astronomy *associate editor Robert Naeye (rnaeye@astronomy.com) is currently writing a children's book about the Chandra X-ray Observatory for Turnstone Publishing Group.*

Are We Alone?

A Washington conference puts the question of extraterrestrial intelligence to the test.

by David J. Eicher

"We have one planet, one example, one history, and we have intelligence," Carl Sagan was fond of saying. "Intelligent species should be spread liberally through the universe."

When Jill Tarter's daughter was 8, her teacher asked her what her mother did. "She searches for little green men," her daughter replied, in perfect deadpan. Tarter is director of Project Phoenix, a privately funded continuation of the Search for Extraterrestrial Intelligence (SETI) whose backing was dropped several years ago by Congress. At the SETI Institute in Mountain View, California, teams of astronomers and engineers continue listening for life in the cosmos. They use an array of borrowed radio telescopes and aspire to construct their own network of dishes dedicated to the task. Convinced of the likelihood of other technological civilizations in the galaxy, Tarter and her colleagues forge an energetic search that may lead to a major discovery or be a monumental waste of time.

"SETI is not an investigation of UFOs, alien abductions, or other pop mythology," says Tarter at the "Cosmic Questions" Conference in Washington last April. "It's not a religion or a cult. It's not a way of directly detecting intelligent life elsewhere in the universe." She bristles at those who dismiss the effort as somehow less scientifically worthy than

Fetal alien from *The X-Files* television series offers one Hollywood take on extraterrestrials. Ken Staniforth/Fox

studying galaxies or planets. "It's not politically correct. it's a suite of scientific explorations that attempts to answer the question, 'Are we alone?' Necessarily a product of our anthropomorphic experience and our limited understanding of the universe we inhabit, SETI is potentially a multigenerational program; we can't predict when or if we will be successful."

Tarter is tall, lithe, and blond; she speaks distinctively in slow tones. Her career served as a model for Jodie Foster's protagonist in *Contact*. She seems to enjoy basking in the afterglow of Hollywood attention but is deadly serious when settling back into a discussion of SETI. How do we find other life? For some experiments, astronomers can actively go on site, Tarter reminds us. That's fine for the solar system, but the stars are too distant. SETI is about passive experiments — the remote sensing of different environments.

Tarter and other scientists gathered to discuss and debate cosmic questions, the existence of intelligent life elsewhere in the universe among them, at the Smithsonian Institution's National Museum of Natural History. The room echoed with the full spectrum of partisanship over the rarity of life in the Galaxy. "NASA and the European Space Agency (ESA) have missions leading up to the Terrestrial Planet Finder and DARWIN. Each will try to make a single pixel image of a terrestrial planet and do a chemical assay of its atmosphere." This procedure could lead to an indirect proclamation about biology on the world being studied.

"But we won't know whether it's algae or alumni," says Tarter. "The only way to detect intelligence, which can't be directly detected over interstellar distances, is with SETI; what the program does is to try to detect manifestations of a distant technology." So SETI's definition of intelligence is a pragmatic one — a civilization with the ability to build a transmitter. The narrowest natural signal, Tarter explains, which arises from an OH maser, occupies 300 hertz; artificial signals are narrower — a fraction of a Hz, for economy's sake.

So SETI scientists conduct two types of searches looking for narrow, electromagnetic signals: sky surveys, looking everywhere without spending much time in any place or frequency, and targeted searches, where astronomers think there's a higher probability of finding a signal. Project Phoenix, the Institute's primary program, is the latter type, a microwave search targeting 1,000 nearby stars, including all known extrasolar planetary systems and the 100 nearest stars regardless of their spectral type.

Life outside of Earth may exist, but *will it have developed brain-like structures capable of higher forms of intelligence?* *The X-Files*, Ken Staniforth/Fox

Phoenix (so named because it rose out of the ashes of Congressional budget cutting) has not yet discovered extraterrestrial intelligence. Thus far, Phoenix says that for about 400 stars, at frequencies between 1.2 and 3 gigahertz, no transmitters were found at the times astronomers looked. The detection limit is equivalent to a strong terrestrial radar. Tarter and her colleagues will continue with the next 600 stars on their list.

Judging the likelihood of other smart life in the universe comes down to a numbers game, for now at least. Many scientists are highly optimistic, drawn to the historical destruction of Earth-centric notions and the numerical vastness of stars. How could one not think that intelligent civilizations are out there? Anthropologist Irven DeVore, Curator of Primatology at Harvard University's Peabody Museum, has no problem playing skeptic. An experienced researcher of baboons, pygmy bushmen, and dolphins, DeVore has been struck by lightning, stung by a 40-foot jellyfish, and victimized by almost every tropical disease known to man — he has learned about life the hard way.

DeVore declares that "the chances that there is anyone out there listening or sending are very slim." He agrees that recent research revealing nucleic acids in cosmic dust demonstrates that life could arise on any reasonable planet. "But remember that for two billion of the first 3.8 billion years of life on this planet, Earth made do with prokaryotes, that is, simple life with no organized nucleus," he says. Biologists think of that period as the age of bacteria or blue-green algae.

"We're not talking about whether there's other life in the universe," says DeVore, "but other intelligent life that we're capable of contacting." DeVore believes the geological record argues: "Evolution is history; it's not a series of predictions. Natural selection, which is the engine driving evolution, is an uncaring, blind process. From the fossil record, we can judge that 99.9 percent of all species that ever lived have gone extinct. There have lived as many as 50 billion species. Of those, only one made civilizations."

So DeVore contends that the evolution of intelligence is highly improbable. He suggested three key words to consider: contingency, catastrophe, and competition. "By contingency I mean an unpredictable series of antecedent events — living species are dependent on all preceding events," says DeVore. "We know of many large catastrophes, such as the Permian-Triassic event, which apparently led to the extinction of 96 percent of all species on Earth at the time, or the much-publicized K-T impact event, which did in the dinosaurs. Cosmic intervention here did mammals a great favor." The dinosaurs were here for 100 million years. Had it not been for cosmic intervention, DeVore reminds us, the small, rat-like mammals scurrying around the dinosaurs's legs would probably still be small, rat-like mammals. Success of a species following a catastrophe likely depends on traits that were not particularly successful before.

Competition is also key. "The rodents got a slow start and then nearly wiped out the primates before we got going well," says DeVore. "What the rodents did was evolve teeth that grew throughout their lives. But primates evolved a peculiar, extremely important adaptation, grasping hands and feet. This allowed them to go up into the branches of trees and harvest fruits and nuts more efficiently than rodents."

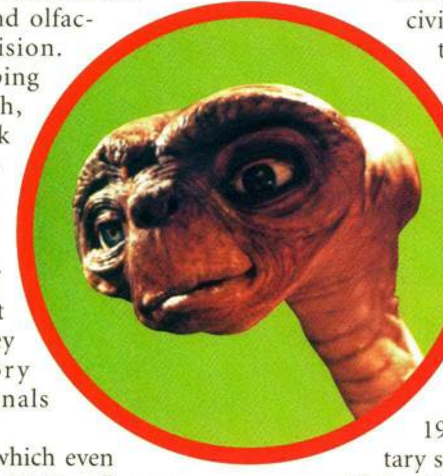
DeVore furthers his argument by describing life in Madagascar, the home of most primates. About 80 percent of living primates exist on Madagascar, which broke away from Africa before monkeys and apes had evolved. The primate species went wild in all directions here, but nothing even vaguely monkey-like was produced. The vast majority of mammals live in a world of tactile sensation and olfaction without color, binocular vision. Binocular vision evolved for leaping from tree branch to tree branch, "because you're taking a big risk every time you leap." So something that evolved long ago in a completely different context turned out to be critically useful 60 million years later. In fact, if there are intelligent beings out there, it's not at all clear that they would have the kind of sensory adaptation to recognize the signals we're sending out, claims DeVore.

"Each time we see the ways in which even sophisticated primates evolved," says DeVore, "we see adaptions that don't include the 'next step' toward ourselves or anything remotely like ourselves."

All this begs the question, What does lead to human intelligence? Monkeys, apes, and humans all share the same kind of brain. They too live in a world of color vision. To get the kind of brain we have is trivial in one sense — one more cellular division and chimps would have brains the size of ours. But they can't afford them. "The brain is an enormously energy-hungry organ," DeVore reminds us. "A sleeping human infant requires up to 80 percent of its energy in maintaining its brain. You have to have placentation to get that greedy organ going. You need others to be a social group to help support the mother through late pregnancy. This occurs nowhere else with primates."

It now appears that Homo habilus led to Homo sapiens. But the somewhat similar Neanderthals, who coexisted with Homo sapiens and were probably very much unlike our species, had brains as large as Homo sapiens. "So there's nothing at all — even with a large brain capacity in an advanced hominid — that guarantees a rise to high intelligence," DeVore claims. "Because of the chain of multiple events that leads from prokaryotes to eukaryotes to mammals to Homo sapiens, I see a complex chain of events that makes the end result of intelligence on Earth extremely unlikely. And chances for communication with other species in the universe are therefore vanishingly small."

Enter Seth Shostak, Public Programs Scientist at the SETI Institute. An entertaining and popular public speaker on alien intelligence and the search, Shostak brings a slightly edgy, high-energy, joke-laden delivery to the floor. A radio astronomer focused on galaxies for much of his career, Shostak seems to enjoy the SETI arguments. His book, *Sharing the Universe*, was published last year to wide acceptance and positive reviews. "SETI is not wasting its time, and the implication of Professor DeVore's remarks, that we will never hear the faint whine of an extraterrestrial civilization because it is nonexistent or extremely rare, is wrong," Shostak flatly states.



Will ET be intelligent and benign, such as was portrayed in the 1982 blockbuster? Universal City Studios & Amblin

The majority of Americans believe that alien civilizations exist, Shostak reminds us. But the existence of intelligent life in the universe won't be settled by popular vote. Is intelligent life truly a rarity? "I can't contest that probability from a biological viewpoint," says Shostak. "Intelligence is surely a specialization, a highly adaptive specialization. The question is not how rare are our brains, but how rare is the functionality of our brains? Brain power does have survival value. Professor DeVore suggests that humans are very special. In the 1920s and 1930s we thought that planetary systems were very special. It was thought until the 1970s that cooking up DNA on a planetary surface was probably very special. But now we know that not only is physics universal, but possibly biology is too." On Earth, life arose quickly — 3.6 or 3.8 billion years ago. This suggests that life might get started easily.

Life in the universe is also probably very different from what we imagine. Consider the aliens produced by Hollywood: heavily anthropomorphic, they're like cowboys whose hats come in only two colors. "There are good aliens such as *ET* who came all the way from the Andromeda Galaxy to pick plants and play with the kids, and he's person-like, even baby-like. Then there are the bad aliens; the ones from *Independence Day*, *Alien*, etc., which look like snakes, reptiles, insects, the sorts of things that we have a natural aversion to." So from Hollywood comes the idea that aliens are going to be soft and squishy, protoplasmic, oozing, mortal. They're going to be an animal species, organized into a society.

"So let's assume that Professor DeVore is correct and intelligence is rare," Shostak continues. "We could still find a universe with intelligent life. Think in terms of deep space: It's dense — there are about 125 billion plus galaxies in the universe, roughly 200 billion stars in our galaxy, and some 10 percent of those are like the sun."

Catastrophes can be defended against more successfully by intelligent species, and self-destruction matters less when intelligence migrates, argues Shostak. When a species spreads out, say, humans to the moon or Mars, then the likelihood for long-term survival also rises. So other civilizations might get through that bottleneck very easily too, and become long-lived.

"Of course the Fermi Paradox argues against this spreading out," concluded Shostak, "by simply asking, 'So where is everybody?'

"Well, if you woke up in the middle of Nevada you might wander about and conclude that you're the only person on the continent. Absence of evidence is not evidence of absence."

This November observers have much to give thanks for as Saturn reaches opposition and Mercury transits the sun.

by Martin Ratcliffe and Alister Ling

This year, instead of falling asleep on the couch after your turkey dinner, why not take the telescope out back and show the family what it is you do on those lonely, dark evenings? A spectacular array of observing highlights from meteor showers to asteroids to a promenade of planets awaits November skywatchers. A glimpse at Saturn or the moon's terminator just may net you a new observing companion.

Will the Leonid meteor shower perform as well or better than last year? No one knows for sure, but a strong shower is expected. If last year's spectacular performance is anything to go by, it's worth staying up all night to see what happens. The shower is rich in swift meteors and fireballs — in 1998 one reached the brightness of the moon as it sped across Kansas skies. Predicting the intensity of a meteor shower, however, is rather like predicting where snowflakes will fall in a snow shower — no one knows until it happens — so make the most of this year's event. The peak most likely will occur on the morning of November 18, but plan to watch for a night either side of that date (see "Last Year's Leonid Lesson," page 73, for more details). In addition, the ancient Taurid meteor shower peaks on November 4. Although it's not one of the stronger showers, these two events give us good odds of seeing at least one meteor this month.

In the United States the clocks changed back to standard time on October 31 — so the dark evenings seem to creep up faster than ever — a boon for observers. This is especially fortunate for younger observers who do not have to fight to stay up so late to see their favorite constellation or planet.

As soon as the sky darkens after sunset, brilliant **Jupiter** can be found high above the southeastern horizon. It shines at magnitude –2.9 and only loses one-tenth of a magnitude during November. The moon, just three days from full, passes 4° south of Jupiter on November 20. The four Galilean moons that orbit

Peter Ward

The moon and Mars hover over San Diego Bay.

NOVEMBER 1999

3 The moon passes 3° north of Venus, 6 P.M. EST

6 Saturn is at opposition, 9 A.M. EST **(page 70)**

7 New moon is at 10:53 P.M. EST

11 The moon is at apogee (252,411 miles from Earth), 12:32 A.M. EST

13 The moon passes 3° north of Mars, 11 A.M. EST

14 The moon passes 0.2° north of Neptune, 10 A.M. EST

15 The moon passes 0.1° north of Uranus, 8 A.M. EST
Mercury is in inferior conjunction, 5 P.M. EST; transits the sun

16 First quarter moon is at 4:03 A.M. EST

17 Leonid meteor shower peaks **(page 73)**

20 The moon passes 4° south of Jupiter, 5 P.M. EST

21 The moon passes 3° south of Saturn, 8 P.M. EST

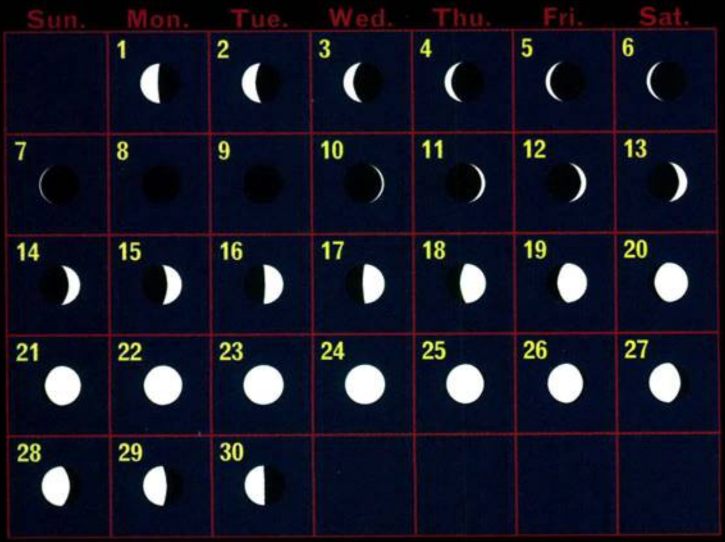
22 Asteroid Kleopatra is at opposition, 6 A.M. EST

23 Full moon is at 2:04 A.M. EST
The moon is at perigee (222,002 miles from Earth), 4:55 P.M. EST
The moon passes 1.3° north of Aldebaran, 5 P.M. EST

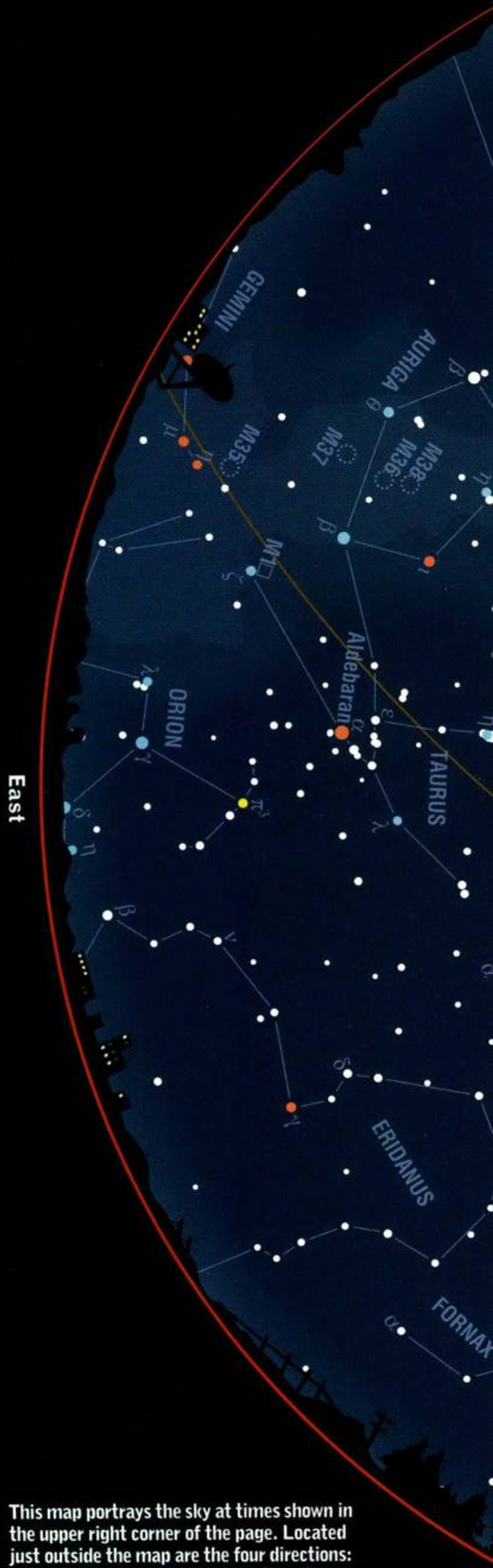
25 Mars is at perihelion (128.4 million miles from the sun), 8 A.M. EST

28 Mars passes 1.7° south of Neptune, 9 A.M. EST
Venus passes 4° north of Spica, 11 P.M. EST

29 Last quarter moon is at 6:18 P.M. EST



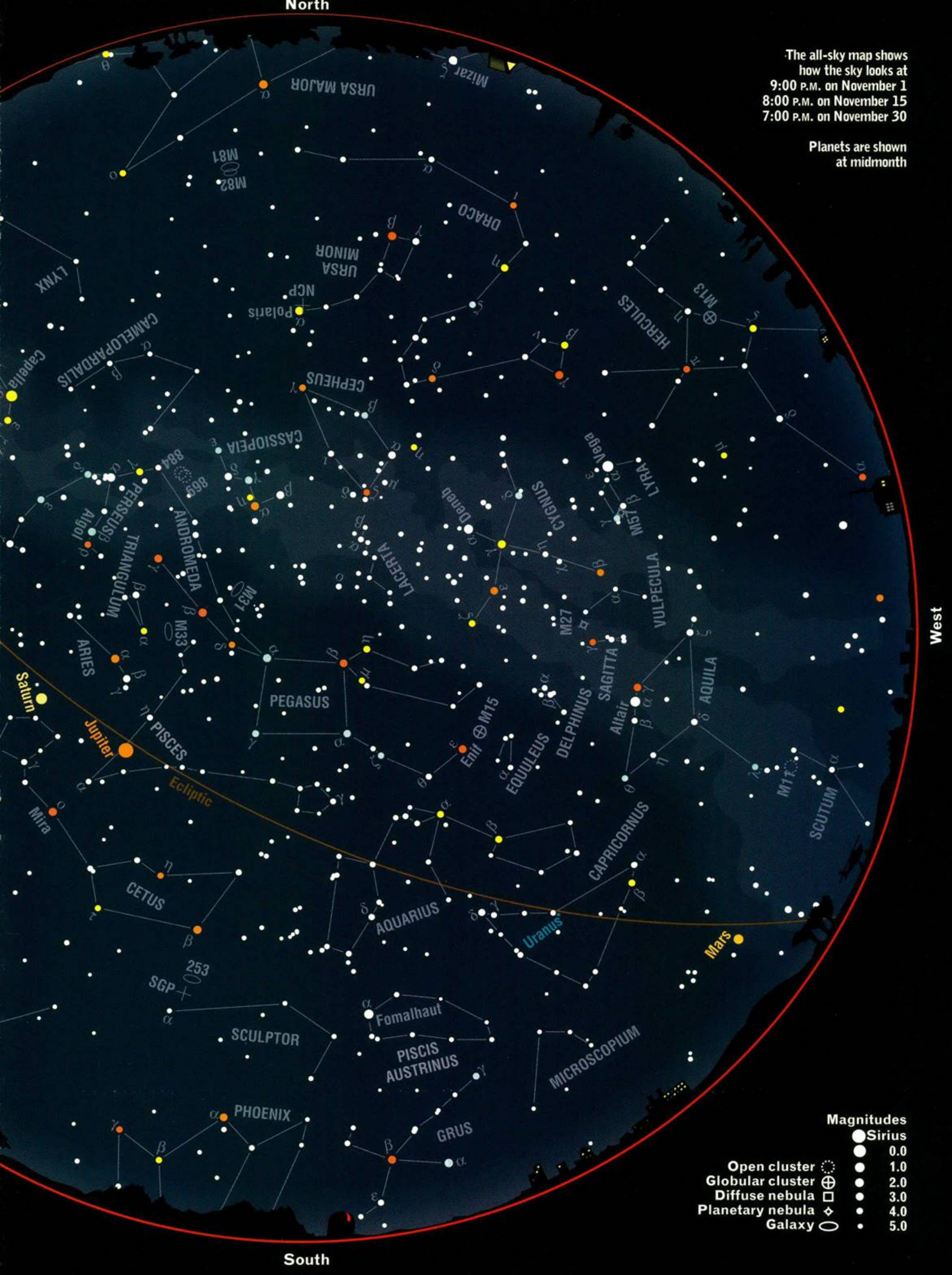
Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				



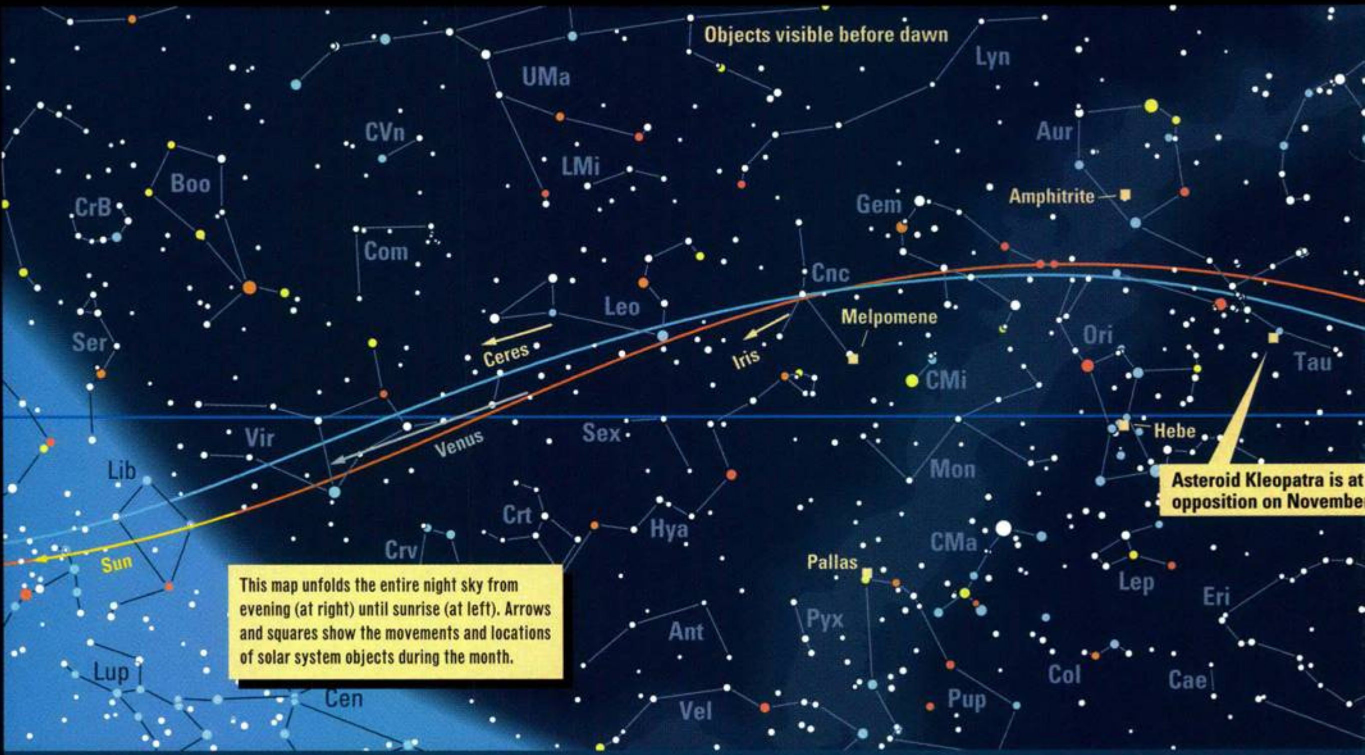
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above *your horizon*, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

The all-sky map shows how the sky looks at
9:00 P.M. on November 1
8:00 P.M. on November 15
7:00 P.M. on November 30

Planets are shown at midmonth

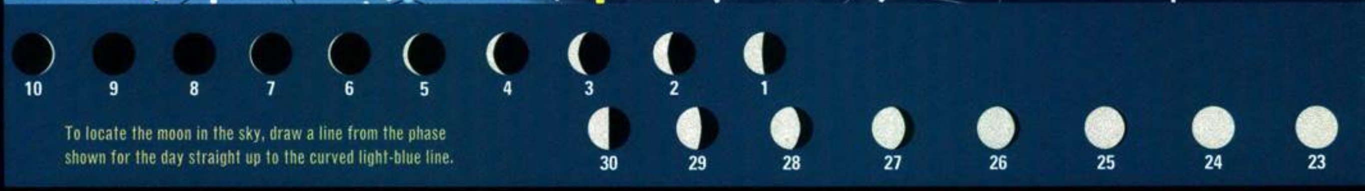

North
South
West
URSA MAJOR
Mizar
M81
M82
DRACO
URSA MINOR
NCP
Polaris
LYNX
CAMELOPARDALIS
Capella
CEPHEUS
CASSIOPEIA
884
869
PERSEUS
Algol
ANDROMEDA
TRIANGULUM
M31
M33
ARIES
HERCULES
M13
LYRA
Vega
M57
CYGNUS
Deneb
LACERTA
VULPECULA
M27
SAGITTA
AQUILA
Altair
DELPHINUS
EQUULEUS
PEGASUS
M15
Enif
PISCES
Saturn
Jupiter
Ecliptic
Mira
CETUS
AQUARIUS
Uranus
CAPRICORNUS
Mars
M11
SCUTUM
SGP
253
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS


Objects visible before dawn
UMa
Lyn
CVn
LMi
Aur
Boo
CrB
Amphitrite
Gem
Com
Cnc
Leo
Melpomene
Ser
Ori
Ceres
Iris
Tau
CMi
Vir
Sex
Hebe
Lib
Venus
Mon
Crt
Sun
Crv
Hya
CMa
Pallas
Lep
Eri
Ant
Pyx
Lup
Cen
Col
Cae
Vel
Pup

Asteroid Kleopatra is at opposition on Novembe

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


10
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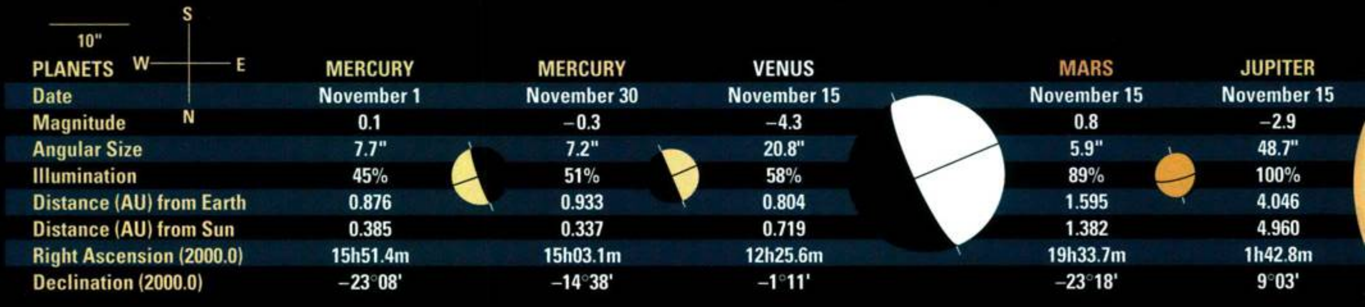
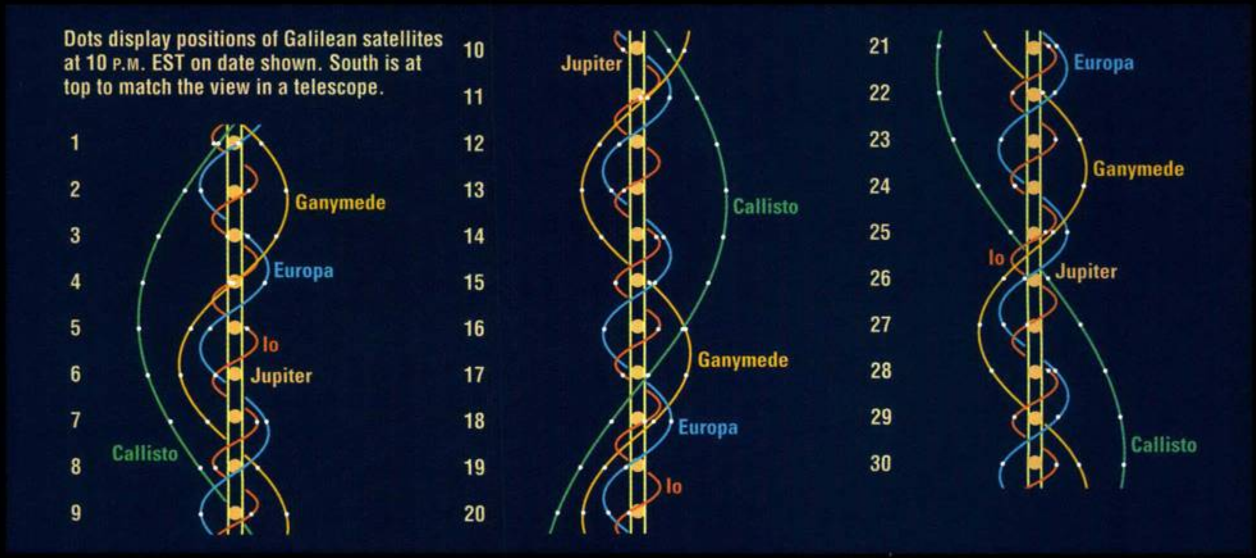
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

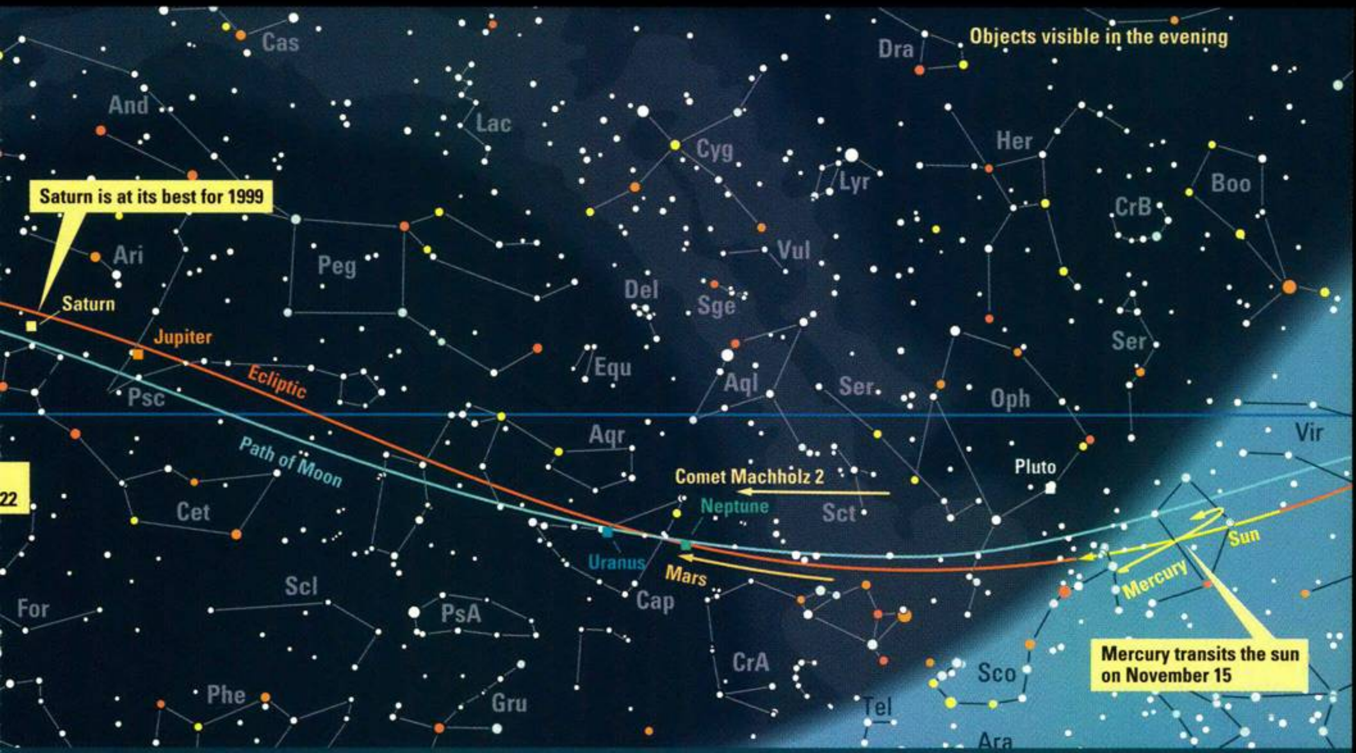


PLANETS	MERCURY	MERCURY	VENUS	MARS	JUPITER
Date	November 1	November 30	November 15	November 15	November 15
Magnitude	0.1	−0.3	−4.3	0.8	−2.9
Angular Size	7.7"	7.2"	20.8"	5.9"	48.7"
Illumination	45%	51%	58%	89%	100%
Distance (AU) from Earth	0.876	0.933	0.804	1.595	4.046
Distance (AU) from Sun	0.385	0.337	0.719	1.382	4.960
Right Ascension (2000.0)	15h51.4m	15h03.1m	12h25.6m	19h33.7m	1h42.8m
Declination (2000.0)	−23°08'	−14°38'	−1°11'	−23°18'	9°03'

JUPITER'S MOONS

Dots display positions of Galilean satellites at 10 P.M. EST on date shown. South is at top to match the view in a telescope.




Cas
And
Lac
Cyg
Lyr
Dra
Her
Boo
CrB
Ari
Peg
Vul
Del
Sge
Ser
Saturn
Jupiter
Ecliptic
Psc
Equ
Aql
Ser
Oph
Vir
Path of Moon
Aqr
Pluto
Comet Machholz 2
22
Cet
Neptune
Sct
Sun
Uranus
Mars
Mercury
Scl
Cap
For
PsA
CrA
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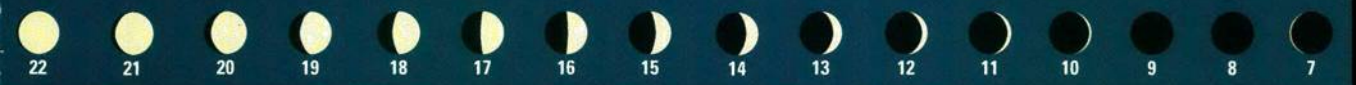
Ara

Objects visible in the evening

Saturn is at its best for 1999

Mercury transits the sun on November 15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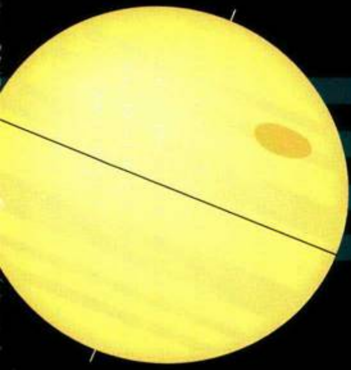
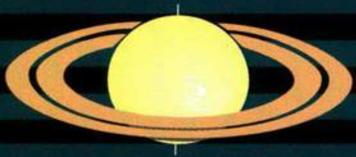
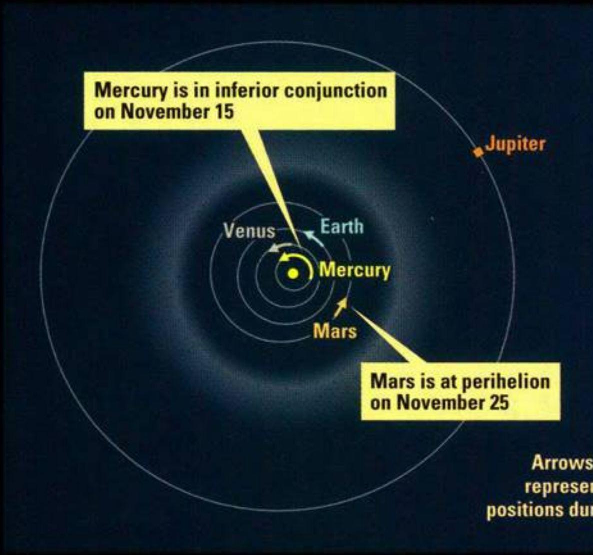



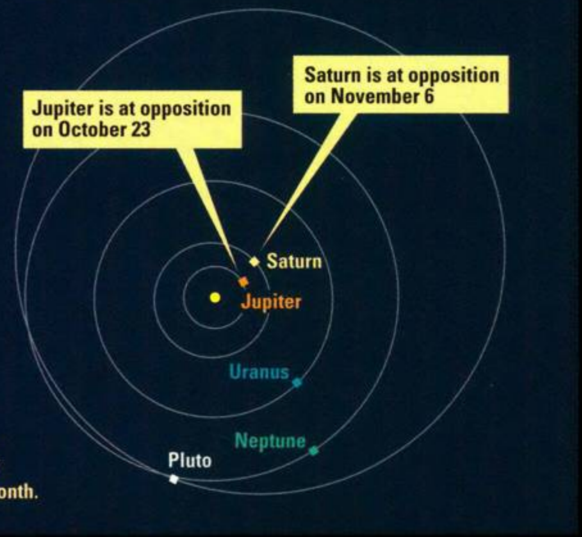
SATURN	NEPTUNE	URANUS	PLUTO
November 15	November 15	November 15	November 15
−0.2	7.9	5.8	13.9
20.2"	2.2"	3.5"	0.1"
100%	100%	100%	100%
8.217	30.451	20.052	31.134
9.194	30.122	19.919	30.210
2h45.5m	20h16.3m	21h03.0m	16h38.6m
13°16'	−19°30'	−17°32'	−11°07'

THE PLANETS IN THEIR ORBITS


Jupiter
Venus
Earth
Mercury
Mars

Mercury is in inferior conjunction on November 15

Mars is at perihelion on November 25

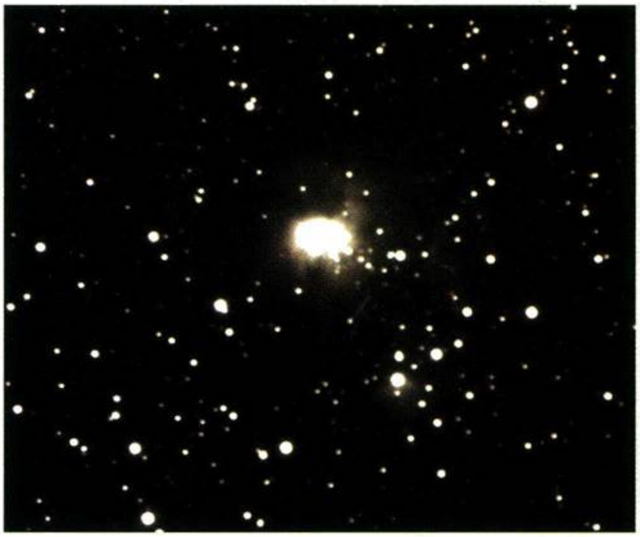

Saturn
Jupiter
Uranus
Neptune
Pluto

Jupiter is at opposition on October 23

Saturn is at opposition on November 6

Arrows and dots represent planets' positions during the month.

FIRST VIEWS: The Comet-like Nebula NGC 1931

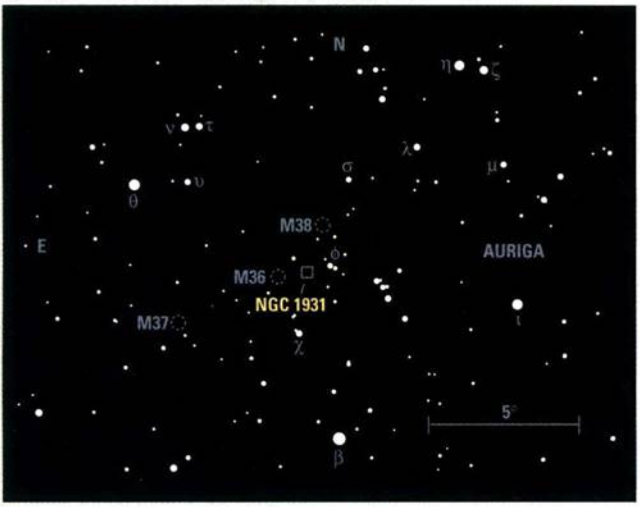


Kim Zussman

If you're a comet hunter, then you will have an adrenaline rush when NGC 1931 first enters the eyepiece. Unlike most galaxies and faint star clusters, this nebula is a really good fake.

At low power, even in a small scope, NGC 1931 has a bright head sporting a weak fan "tail" of nebulosity, like many comets. Under a dark sky, I first tracked down this object, which contains reflection and emission nebulosity, in a 2.4-inch (60-mm) refractor at 40x. The nebula's coordinates are 5h31.4m R.A., 34°15' Dec., placing it almost exactly 1° west of the bright star cluster M36.

Nebulae come in two basic types, emission and reflection. When a star is hot enough, it emits ultraviolet light causing nearby gas clouds to fluoresce — to shine in visible light. Astrophotos show these objects as red patches, and a nebula filter will bring them out nicely. On the other hand, if the nearby star is too cool, a surrounding cloud of dust might simply scatter the starlight, producing a blue-white glow. The Merope Nebula (NGC 1435), the cloudy streaks visible around the star Merope in the Pleiades, is produced by this type of dust reflection. A nebula filter will not enhance NGC 1931 much because it's dominated by reflection nebulosity and doesn't produce much of its own light. This means it is also probably too dim to find from a city.



All illustrations by *Astronomy*: Elisabeth Rowan

Head out to dark skies in the first two weeks of the month. In bigger scopes, boost the power to 200x or more to get a closer look. The "comet head" turns out to be four closely spaced stars, with a few more nearby. The edges of the nebulosity are ill-defined, somewhat similar to that of a comet.

If you master NGC 1931, you may be able to spot an interloper just to its south. By the 16th, asteroid Amphitrite will be making a visit to the neighborhood (see "Amphitrite Cruises Past Clusters," page 70).

Jupiter — Io, Europa, Ganymede, and Callisto — are easily visible through any telescope as they dance around the planet. And no, your eyes aren't fooling you. For the first half of the month Jupiter does appear to gain another moon as the planet glides close to the magnitude 4.3 star Omicron (o) Piscium.

Lying farther out in the solar system but in a similar direction as Jupiter, **Saturn** reaches opposition on November 6. This places it exactly opposite the sun in the sky, where it stands above the eastern horizon soon after dusk. It trails 16° east of Jupiter, or roughly one hand-span held at arm's length, and lies in the constellation Aries the Ram. The Ringed Planet appears like a dimmer "star" than Jupiter, shining at magnitude 0. Telescopically Saturn is a thrill, with its rings tilted almost 20° to our line of sight so that we can see their southern face. The planet's disk spans about 18" across, one-third of Jupiter's giant disk. However, the rings make up for this shortcoming — the long axis of Saturn's rings reaches 45" wide. Saturn's brightest moon is Titan, target of NASA's Huygens probe to be launched from the orbiter Cassini due to arrive in 2004. This moon, unusual among the solar system's satellites because of its substantial atmosphere, was discovered by Christiaan Huygens in 1655. Titan can be viewed through small telescopes because it shines at magnitude 8.3. It passes due north of Saturn on November 2 and 18, and due south on November 10 and 26.

Compared to Saturn, **Mars** is our near neighbor. During the early evenings Mars can be found lingering in Sagittarius, now setting in the southwest a couple hours after darkness. Mars moves in an easterly direction from night to night relative to the stars. At magnitude 0.8, it moves away from the teapot handle of Sagittarius. A fine five-day-old crescent moon stands 4° northeast of Mars on

November 13. There is little visible in its 6" diameter disk these days, and the interest in Mars now lies in how long it takes to disappear into the sun's twilight. It will linger in the evening sky for some months yet.

Mars passes into Capricornus on November 26 and lies 1.7° south of **Neptune** on November 28. Neptune can only be viewed using a telescope or large binoculars. It glows at magnitude 8.0 and lies near the 5.3-magnitude star Sigma (σ) Capricorni.

Uranus continues to wander slowly in its 84-year orbit around the sun. The seventh planet halts its westward slide relative to the stars and resumes its easterly track once again. Shining at an easy magnitude 5.8, the greenish Uranus can be spotted in binoculars as it strays back into the neighborhood of Theta (θ) Capricorni.

High above this activity the faint remnant of Comet Lee cruises among the western portions of Andromeda. Now a dim magnitude 11, it's a worthy opponent for any who take the Observer's Challenge (page 72).

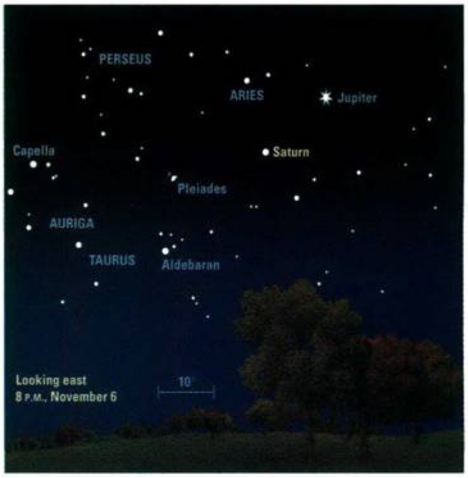
You don't have to be a night owl to enjoy this month's rare planetary passage — on November 15, we move to daytime. The innermost planet, **Mercury**, passes directly between the sun and Earth, undergoing a rare transit of the sun. The last such transit occurred in November 1993, and the last one visible from the United States was in November 1973. Mercury will just graze inside the limb of the sun around 4:15 P.M. EST, and the midpoint of the transit occurs 26 minutes later. Mercury will apppear as a tiny 10" diame-

Saturn's Shadows

Just because you won't be able to see Saturn's shadow on the 6th doesn't mean there'll be an early spring. What it does mean is that Saturn has reached opposition, which is when the sun, Earth, and the planet all line up. It's no coincidence that Saturn is at its brightest, magnitude –0.2, because every part of Saturn that we can see is reflecting light back toward us.

It will take almost this full month before the lineup has changed enough that we can peer a bit behind Saturn. Look for a dark, thin line just beyond the cloud tops where they block out sunlight hitting the rings. It will be to the east side of the planet. To find east, shut off the clock drive on your telescope and east will be the edge that disappears last.

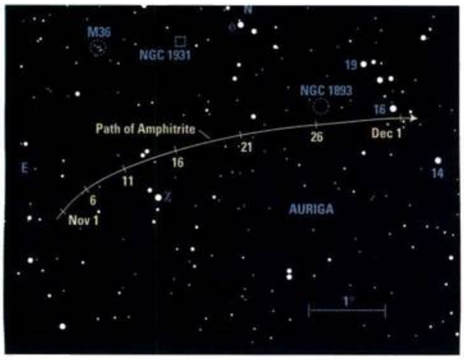
Another shadow will be visible during opposition. Look closely at the area where the rings cut in front of Saturn. You should be able to see a dusky band that at first might look like a cloud belt. What you are seeing is the effect of the crepe (C) ring's thin veil. Sunlight dims slightly as it passes through the crepe and feebly illuminates the cloud tops underneath. If the sky is very transparent and steady, you may be able to see the ghostly crepe itself at the inside edge of the rings. Generally a 6-inch scope with clean optics is the minimum requirements for catching such a view. (See "Falling for Jupiter and Saturn," October 1999.)



Amphitrite Cruises Past Clusters

Just about every month a rocky denizen of our solar system slowly glides past interesting objects that in reality lie far in the background of space. This month the 29th asteroid to be discovered, Amphitrite, will be our guide into the deep.

This 135-mile (220-km) mountain glows at magnitude 9.5, equal to the brightness of many individual stars in the clusters M36 and M38 in southern Auriga.



During the first week of November, Amphitrite lies about 1.5° (3 moon diameters) south of M36.

A bit more than 1° from M36 and Amphitrite lies a fascinating, comet-like nebula, NGC 1931 (see "First Views," page 69). On the 13th, the asteroid slides 6' south of a pair of magnitude 6.5 stars, which should give you a reference marker to note Amphitrite's motion. Just past full moon on Thanksgiving (the 25th), it skirts the southern edge of star cluster NGC 1893.

There's also a bonus asteroid and nebula lurking nearby Amphitrite: 359 Georgia sails a parallel course (only 30' west-southwest of Amphitrite) during the whole month. Its feeble glow at magnitude 13.2 will require a big scope and a dark sky. If you're able to reach asteroid Georgia, next try to spot the odd, faint reflection nebula NGC 1985 that lies another 30' south-southwest during the first week of November.

ter black disk slowly crossing the sun's face. The entire event lasts just 52 minutes.

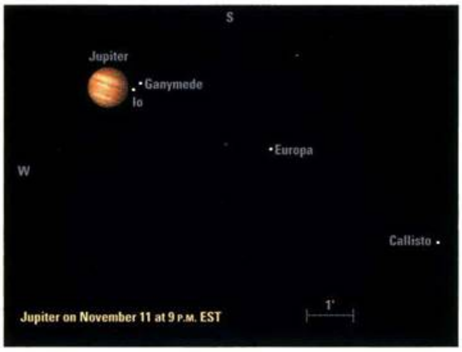
The best way to view the transit is to project an image of the sun onto a white card. With your telescope pointing at the sun, hold a large piece of card about six inches from the end of the eyepiece so that the sun's orb is cast onto it. Stand between the sun and the card in order to cast your shadow onto the card, so that the only sunlight hitting the card is what comes through the telescope's tube.

Watch for the growing numbers of sunspots on the sun as solar maximum approaches. If there are any sunspots visible during the transit, note how much darker the disk of Mercury appears in comparison to the sunspots. Sunspots are still quite hot, only appearing dark in contrast to the surrounding blinding photosphere. (See "Adrift on the Sun," page 76.)

Returning to the night sky of November, Mira (Omicron Ceti), the most famous of all long period variables, should peak in brightness this month. Originally believed to be a nova, Mira means "the wonderful" in Latin. Situated in the constellation of Cetus the Whale, Mira should be easily visible to the unaided eye as a magnitude 3 star lying a little to the south of Saturn. Mira does not behave the same way each year. Some years its maximum brightness can be equivalent to Aldebaran; other years it fails to reach magnitude 4. You can use some of the nearby stars as comparisons — Alpha (α) Ceti is magnitude 2.7, Gamma (γ) Ceti is magnitude 3.6, and Delta (δ) Ceti

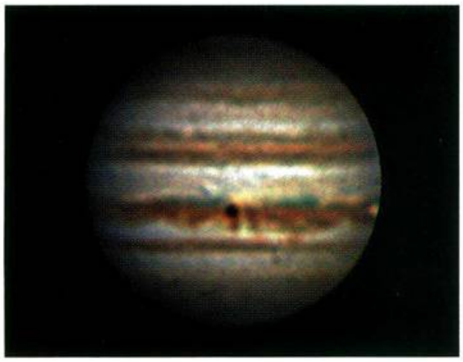
A Gathering of Galilean Moons

Don't miss out on seeing a double shadow on Jupiter the evening of the 4th. Ganymede and Io are already in front of Jupiter, having crossed at 7:23 and 7:42 P.M. EST (4:42 P.M. PST). Io's shadow is cast on the cloud tops at 8:01 while Ganymede's shadow follows at 8:32. The double shadow event ends at 10:11 P.M. as Io's shadow leaves. Fortunately, observers on the west coast only miss the beginning.



Jupiter on November 11 at 9 P.M. EST

Is it possible to see all four of Jupiter's bright moons together on one side of the planet? It sure is. Such Galilean groupings occur roughly four times a month, although a couple are bound to happen in daylight.


Don Parker

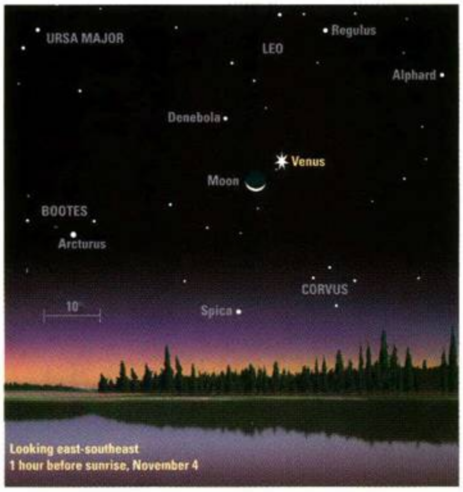
On the evening of November 11, you have until 9:26 P.M. EST (6:26 P.M. PST) to see four moons on one side. After this, Io begins its transit in front of the cloud tops, followed 30 minutes later by its darker and easier-to-see shadow. Ganymede's transit begins at 10:40 P.M.

A replay with all the jovian moons on the other side of the planet begins on the 20th, at 7:47 P.M. EST, when Io edges into view on the western side. Its shadow can be seen sliding across the cloud tops for another 45 minutes.

Venus Points to Spring

As winter looms close by, Venus shows us that spring cannot be far behind. Just before dawn, Regulus already sits high above the blazing magnitude –4.3 beacon. By the end of the month, Spica rises up from the horizon to be one binocular field from Venus. To most stargazers, Spica is a clear signal of spring. This blue-white star reaches due south when greenery returns. Till then, it's not too long to wait.

On the mornings of the 3rd and 4th, about 45 minutes before sunrise, watch for the pretty crescent moon pairing with the goddess of love, Venus.



Looking east-southeast
1 hour before sunrise, November 4

Technically, Venus reaches exactly half phase, dichotomy, on October 30th, but, due to its clouds, it will not appear like a half moon for another few days. Venus has a fatter phase than the moon because it is advancing toward the backside of the sun and becoming more and more lit, whereas the moon is slowly moving in between Earth and the sun. So the farther away Venus moves, the more of its face we see.

Observer's Challenge: Comet Lee

If you live in a big city, nothing short of a blackout will allow you to see fading Comet Lee (C/1999 H1) as it zooms out of our neighborhood. Because Y2K possibilities are still over a month away, you'd better just head off to dark-sky territory and not count on a power failure.

Seriously, it's a lot of fun following comets across the sky as they brighten toward perihelion, their close approach to the sun, then fade away as they retreat toward the edges of our solar system.

This month, Comet Lee fades from 11th to 12th magnitude, meaning you'll typically need an 8-inch scope to detect this faint fuzzball. Before you jump to Comet Lee, you must check out the nearby bright, beautiful barred spiral galaxy NGC 7479, 2.7° due south of Alpha (α) Pegasi. Don't be fooled by the field stars masquerading as supernovae.

Lee starts off the month less than 2° east of NGC 7280, a 12.1-magnitude, roundish object. One degree northeast of NGC 7280 lies NGC 7290, a 13.8-magnitude galaxy. With a 12-inch scope, you'll likely need to go to medium power, both to increase the size of the galaxy and darken the background sky.

Who knows? By the time you read this, perhaps a new comet will be much brighter than Lee. The Internet is a good tool for keeping tabs on comets. Head to http://encke.jpl.nasa.gov/index.html.

Gerald Rhemann and Franz Kersche

is magnitude 4.1. Discover for yourself how bright it becomes this month. Mira can dim to magnitude 9 or fainter — watch it fade over the next few months. See how long you can follow it.

As Mira rises in the eastern sky, the stars of summer are slowly sinking in the west, to be replaced by the Great Square of Pegasus that hangs almost overhead for latitudes around 40° north. At the eastern end of Andromeda lies Epsilon (ε) Pegasi, and 4° to its northwest is M15, a spectacular globular cluster shining at magnitude 6.3. This cluster is relatively easy to spot in binoculars, makes for a fine sight in a telescope, and can even withstand some high magnification.

Nestling on the eastern side of Andromeda is Pisces the Fish, currently accommodating Jupiter in its easternmost corner. North of Jupiter lie the two small constellations Aries the Ram and Triangulum. Triangulum contains the beautiful but faint M33 — best viewed with binoculars or a rich-field telescope. Keep your magnification down on this galaxy — it's a face-on spiral of low surface brightness. In neighboring Andromeda is the great galaxy M31. This local gem, visible to the naked eye on dark nights, passes almost overhead by late evening. Its two companion elliptical galaxies are easy targets for small scopes.

The 1st-magnitude star low in the south on November evenings is Fomalhaut — found by extending a line down the right side of the square of Pegasus toward the southern horizon. Fomalhaut is the predominant star in the constellation of Piscis Austrinus, the Southern Fish. Between Fomalhaut and Pegasus in this dim region of sky lies Aquarius the Water-bearer.

Rising in the eastern sky are the winter stars, led by Taurus. Indeed, many observers see the Pleiades rising as a chilling reminder that winter is on its way. Soon after the Pleiades, Aldebaran, the red eye of the Bull, makes its striking presence felt. To its northeast, Auriga the Charioteer follows Perseus high into the night sky. High to the north, the "W" of Cassiopeia swings through its upper culmination as the Big Dipper grazes the northern horizon.

Through the night and into the early morning hours, the stars make their gentle way from east to west, carried by Earth's daily rotation. This motion is illustrated by time-lapse photography of star trails wheeling across a black dome. By 3 A.M. Orion is high in the sky, and Leo is rising in the east.

The asteroid Ceres makes an interesting trek past two well-known galaxies, M65 and M66 in Leo. Ceres is the largest asteroid in the solar system and passes less than a half degree due north of M65 on November 3 and north of M66 a day later. The galaxies will be a challenge to see, however, because a crescent moon lies 5° south of the galaxy pair. By comparison, magnitude 8.7 Ceres should be easy to see. A large telescope will help in detecting the galaxies in this interesting lineup. Check the field on both nights to pick out the interloper.

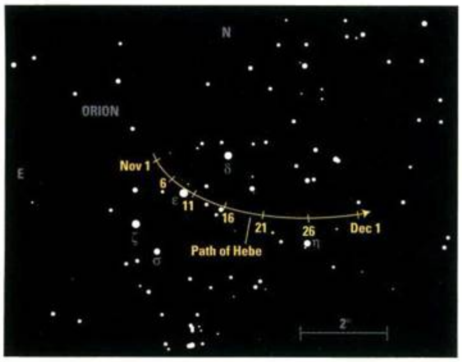
Another asteroid worth watching this month is 6 Hebe. It dives through the belt of Orion traveling from north to south, passing between Mintaka and Alnilam on November 4. Hebe is approaching opposition early next month and begins November shining at magnitude 8.6. Lying in the rich star fields of Orion, correctly identifying Hebe will make an interesting challenge with so many other 8th-magnitude stars, but its southerly motion from night to night should betray it (see "Hebe Buckles Orion's Belt").

For early risers, Mercury leaps away from the glare of the sun for a brief appearance in the morning sky at the end of the month. The fleet-footed planet shines at magnitude –0.3 on the last day of November. Joining the early morning activity, the dazzling planet **Venus** shines at magnitude –4.1 in the rosy predawn sky. On November 3 it follows the moon rising shortly after 4 A.M. local time. Venus begins the month 50 percent illuminated and grows to a gibbous phase late in the month. Concurrently its apparent diameter shrinks from 23" down to 18" — a result of its increasing distance. In the coming years, Venus will have a radiant rival. When the International Space Station is completed, only Venus and the moon will outshine it in the night sky. **A**

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

Hebe Buckles Orion's Belt

Maybe you've never heard of it, but 6 Hebe has to be one of the easiest asteroids to find. If you have a modest telescope and can locate the middle star of Orion's belt, known as Alnilam (ε), you've got a chance. For two weeks Hebe will be no more than 1° (two moon widths) from bright Alnilam.



The sixth asteroid to be discovered, Hebe stretches 120 miles across (190 km) and sports a brightness of magnitude 8.7, easy to catch in the smallest of telescopes. Using the chart on pages 65 and 66 and magnifications at 100x or higher, you can use field stars to track the orbiting mountain as it moves. In a couple hours you should be able to see that it has changed position.

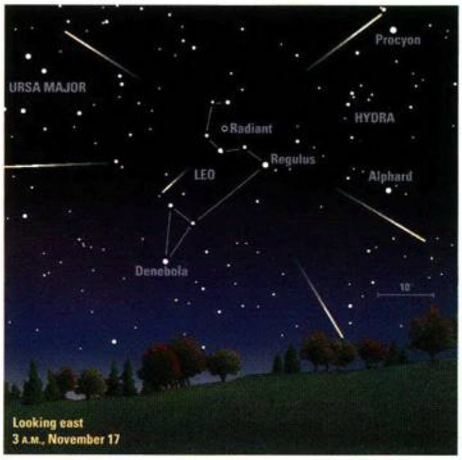
You can watch Hebe approach a 7.6-magnitude star on the evening of the 4th and an 8th-magnitude star on the 7th. Can you still spot Hebe during the nights of November 8–10 when it lies less than 7' (¼ moon width) from the middle belt star of Orion?

Last Year's Leonid Lesson

The one event that many people have been anticipating all year is this month's Leonid meteor shower. Astronomers predict less activity than last year, but just as with rain showers, predictions for meteor showers can be equally uncertain.

The lesson learned after last year's wonderful, heavy flurry of meteors is this: Don't take any chances; observe for at least three nights, from Tuesday the 16th until the morning of Friday the 19th. Last year, the fireballs reached a peak 16 hours before the expected maximum, so many folks observed a day too late. Those who were treated to the show were wowed by fireballs brightening the sky every few minutes until the sun rose.

Michael Klensch



Looking east
3 A.M., November 17

Dust and pebbles from Comet Tempel-Tuttle's tail disintegrate in the upper atmosphere producing the swift "shooting stars" and fireballs, called bolides. Due to a waxing quarter moon, the fainter meteors will be hard to see, but any bolides will still induce "ahs" from the crowds. Give yourself and your neighbors a better chance by turning off exterior lights. Then bundle up, bring warm drinks, and invite friends to watch the action.

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By Philip S. Harrington

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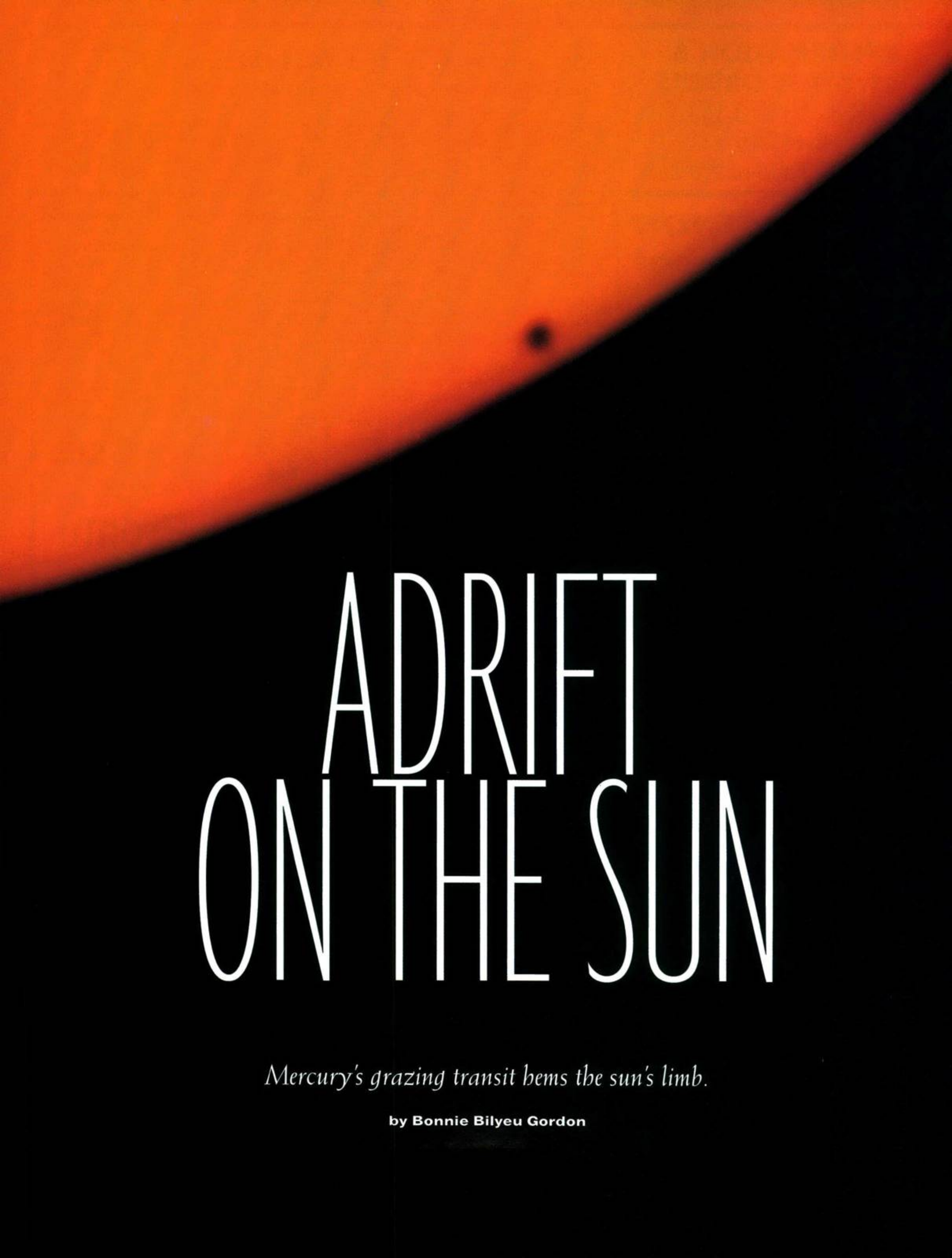
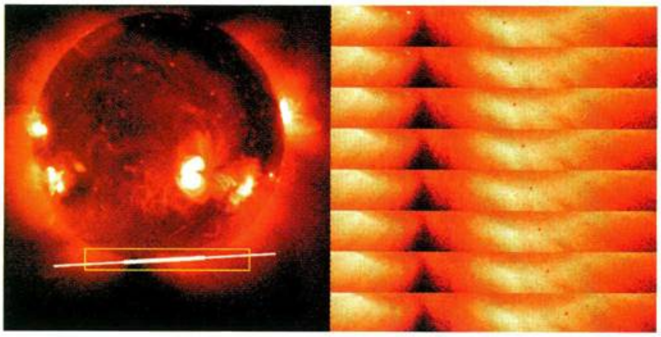


ADRIFT ON THE SUN

Mercury's grazing transit hems the sun's limb.

by Bonnie Bilyeu Gordon

The last time most North Americans could watch Mercury cut a slow path across the face of the sun — called a transit of Mercury — was 26 years ago. During a transit, Mercury resembles nothing more than a round, black speck on the face of the sun — underscoring the sun's huge size and the distance and smallness of the planet. Still, the rarity of the event draws fans with their telescopes into the cold November light.



On November 6, 1993, the soft x-ray telescope on the Yohkoh satellite captured Mercury's transit at four to five minute intervals. ISAS/NASA

On its last two transits, Mercury's crossing was missed in North America because the sun had already set. These unique spectacles could be seen only from the Eastern Hemisphere (and the far western Aleutian Islands). This year, on November 15, we can watch Mercury transit as the planet's orbit takes it directly between Earth and the sun. That's if the sun is shining in our own backyards and we have at least a 2-inch telescope with a solar filter. This transit of Mercury will be all the more exceptional because the planet's path moves across the northeastern limb of the sun, just hemming the sun's edge, earning the name "grazing transit."

A transit occurs when either of the two inner planets, Venus or Mercury, comes exactly between the sun and Earth. Though Mercury's silhouette against the sun requires magnification to be seen, when Venus crosses the sun's path, it is barely visible to the naked (solar-filtered) eye. At 64" across, it's more than six times larger than Mercury will appear this year.

Mercury and Venus regularly pass almost between Earth and the sun at inferior conjunctions. (An inner planet has an inferior conjunction when it passes between the sun and Earth, and a superior conjunction when it lies on the far side of the sun from Earth.) Transits, however, don't occur with each inferior conjunction because the orbits of the inner planets and the orbit of Earth are not perfectly aligned. The orbital plane of Mercury is inclined to the orbital plane of Earth, or the ecliptic, by 7°. The orbit of Venus is inclined to the ecliptic by 3.5°. The two inner planets spend most of their time either north or south of Earth's orbital plane, so they pass north or south of the sun during most inferior conjunctions.

Two times in its 88-day orbit of the sun, Mercury crosses the orbital plane of Earth, and two times in each 243-day venusian orbit, Venus shares Earth's orbital plane. When inferior conjunction coincides with these passages through the ecliptic, a transit occurs. But Mercury's rare transits occur only 13 or 14 times a century — and only around May 8 and November 10. (During November transits when the planet is at perihelion, Mercury appears to be 10" in diameter, while it appears to be 12" in diameter when the planet is at aphelion in rarer May transits.) Mercury's last transit occurred November 6, 1993, and the one before that was on November 13, 1986. The last one visible from the Western Hemisphere, however, occurred in 1973 — 26 years ago.

Transits of Venus are rarer still, occurring only twice in one century and paired eight years apart. Their rarity derives from Venus's much slower orbit, which offers fewer opportunities for inferior conjunction. The last venusian transit occurred in 1882, but a long-awaited pair of them are coming right up. One will occur on June 8, 2004, and one on June 6, 2012.

If everything goes well — the skies are clear, the sun is out, and you have a telescope with a solar filter — Mercury will appear as a tiny black dot. To make sure that you don't confuse Mercury with a sunspot, look for a solid disk whose silhouette moves slowly along the path shown on page 78. The solar maximum (when the sun is its most active) is upon us and sunspot activity has increased, but sunspots are usually larger than the dot that is Mercury and sunspots have more irregular shapes, often mottled with grays.

By description, the transit of Mercury may seem a bit less than awe inspiring, something that visually resembles an ant crossing a saucer, but remind yourself that you are looking at one of only two planets that cross between Earth and the sun. If you think about it this way, you'll begin to understand the nature of our solar system a little better. Watching a transit also demonstrates almost viscerally the size differences between the sun and the planets. Because Mercury is 40 percent as big as Earth, Earth would appear about twice the size of Mercury if seen transiting the sun from an outer planet at a similar distance. Plus, this is one of those unusual moments in skywatching, not unlike an eclipse, when you actually can detect movement — and in daylight. In fact, the various stages of a transit carry the same labels as those for an annular eclipse.

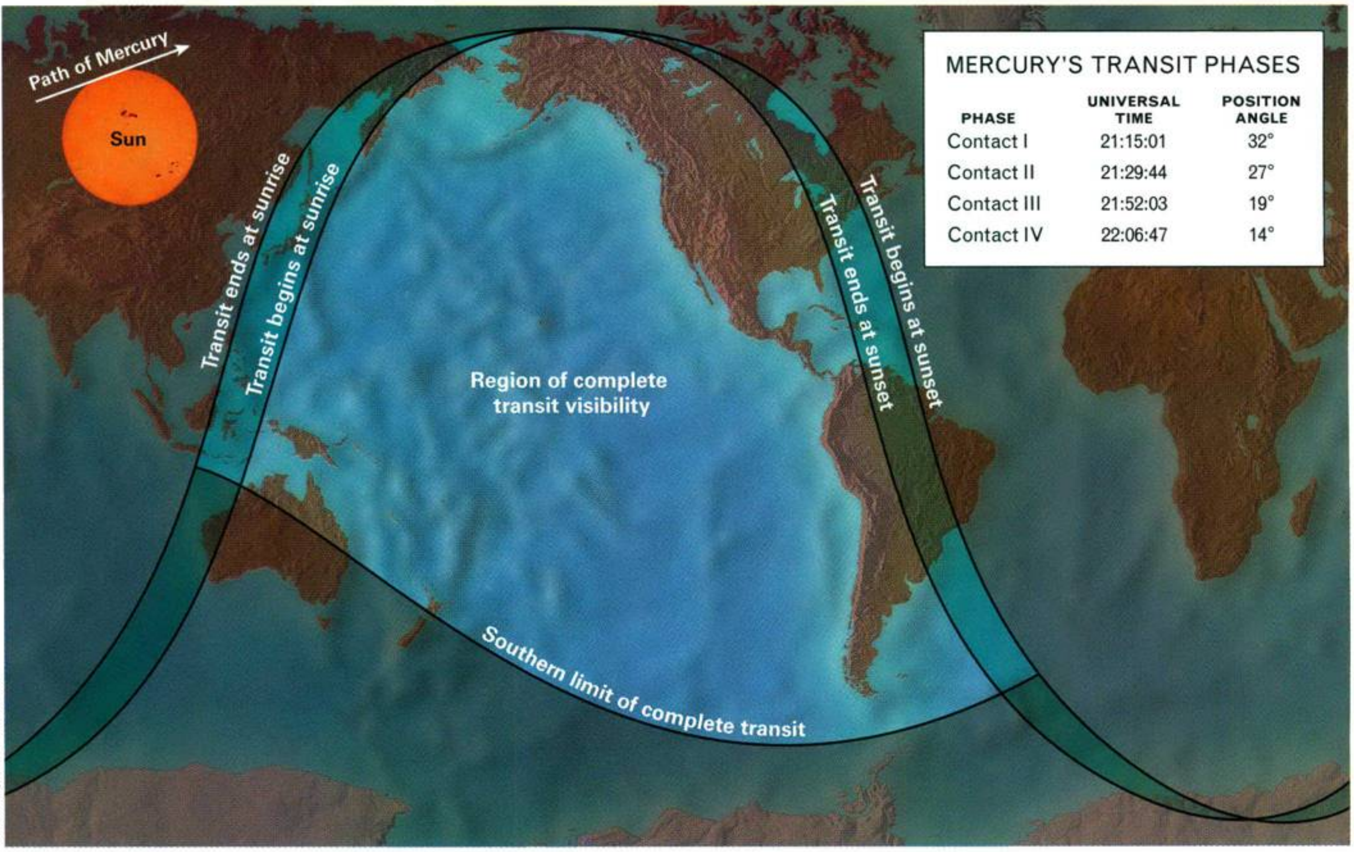
SAFE VIEWING

Be absolutely sure you have a good solar filter securely attached over the front end of your telescope. Don't risk looking toward the sun, especially through a telescope that magnifies its power, unless your eyes are protected. It would be much better to miss seeing a transit than to have it be the last thing you see.

A full-aperture solar filter will reduce the sun's intensity by 100,000 times, which guarantees safe viewing directly through the scope. But if you don't have a solar filter or you aren't sure if yours is adequate, you can use solar projection to watch the transit. Project the image of the sun formed by the telescope onto a screen a couple of feet from the eyepiece. Stop the aperture down to 3 or 4 inches to compensate for brightness.

Make sure everyone is warned to stay away from the path of light as it exits the telescope because they can be badly burned by it. Turn your telescope away from the sun every now and then to prevent overheating. Use only low-magnification eyepieces. And remember that your best eyepieces can be damaged if they contain lenses cemented together.

Mercury's small disk is dwarfed by the sun. H. P. Arnold


Path of Mercury
Sun
Transit ends at sunrise
Transit begins at sunrise
Region of complete transit visibility
Transit ends at sunset
Transit begins at sunset
Southern limit of complete transit

MERCURY'S TRANSIT PHASES

PHASE	UNIVERSAL TIME	POSITION ANGLE
Contact I	21:15:01	32°
Contact II	21:29:44	27°
Contact III	21:52:03	19°
Contact IV	22:06:47	14°

Astronomy: Elisabeth Rowan

The moment Mercury makes contact with the sun is called Contact I, the same phrase used to describe the first instant of an annular eclipse. On November 15, 1999, Contact I occurs at 21:15 Universal Time. (Universal or Greenwich Time is five hours later than Eastern Standard Time, so Contact I occurs at 4:15 P.M. EST.)

Shortly after Contact I, the disk of Mercury will make a tiny notch in the northeastern edge of the solar disk, and when the entire mercurian disk is visible, Contact II has begun. During the next hour, the planet's disk will move slowly across the sun's brilliant surface until it reaches the far edge and is internally tangent with the solar limb, Contact III. As the planet exits the sun's limb, the transit ends in Contact IV.

For obvious reasons, a grazing transit is much briefer than other transits, which can last several hours. A grazing transit also assures that phase times may vary as much as ten minutes depending on the location of the viewer. In the mid-Pacific, the contacts will be nearly as stated above. From North America, ingress (Contacts I and II) will occur earlier and egress (Contacts III and IV) will occur later. From the far southern reaches of the partial transit zone, Contact II and III will fade into one another.

The region where Mercury's transit is visible (its shadow cone) is about 1.9 million miles wide, and Earth's diameter is only about 8,000 miles, assuring that when a transit occurs, it can be seen from the entire daylight side of Earth. On November 15, this includes the South Pacific, northeastern Australia, Hawaii, western South America, and most of North America, where it occurs just before sunset. Observers in most of Australia, New Zealand, and Antarctica will see a partial transit, as shown in the map above. But wherever you are, you need at least a 2-inch telescope and solar protection as described in the Safe Viewing box.

Compared to views of supernova remnants and nebulae through a professional telescope, the view of a transit is a dynamic event only visible on rare opportunites. The next transit of Mercury won't occur until May 7, 2003, and will be followed a year later by the transit of Venus. Most observers in North America will be able to watch the 2004 venusian transit — the first in 121 years.

TIPS FOR PHOTOGRAPHERS

1. Shoot through a solar-filtered telescope in a wide range of exposures as you would for a solar eclipse.
2. Use a focal ratio in the range of f/60 to f/125 to capture the transit.
3. A fine grain film will give the best results.
4. This grazing transit may require longer exposure times than most, because the planet's path is so near the darker limb of the sun.

CONTRIBUTE TO SCIENCE

If you want to help refine scientific research on the position and diameter of Mercury, you can measure the time it takes this diminutive planet to edge across the sun. Record the exact measurements of the four contact phases of the transit. Send observations and your exact geographic coordinates to Almanac Office, U.S. Naval Observatory, Washington, D.C. 20390.

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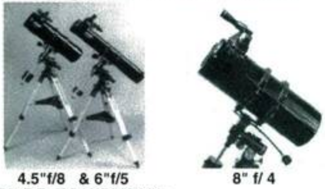

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The Sinister Sky

Autumn nights bring out eerie tales of terror.

by Bob Berman

Is astronomy nerdy? Let anyone who thinks so try stargazing on a November night when barren branches tremble in the wind. Let detractors step under an icy Halloween sky to ponder the eerie mythology of autumn constellations. Gather round the campfire. I'm here to tell bloodcurdling tales of the sky's sinister side — the danger, the romance, the reason astronomers deserve to flex biceps with the best of them. After all, what other hobby takes place entirely in the dark? (Okay, besides that one.) What other devotees stand bravely outdoors on the blackest of nights and then ask nearby homeowners to douse their lights as well? Even more daringly, we're often alone. Seldom can we coax others to join us in freezing fall weather to stare at a little blob we insist is a galaxy.

Mike Waraksa

In exploring the sky's "dark side," it's tempting to make cute Halloween quips about Boo!-tes and Beetle-juice. But autumn evokes actual, deep-seated, foreboding aspects to the heavens that involve celestial danger and ominous cultural lore. There's no shortage of melancholy autumn myths, possibly because the season's dying plants and falling leaves have never suggested that gleeful months lie ahead. Moreover, the night sky epitomizes darkness and mystery, giving widespread civilizations an uneasy dread that went beyond primordial fear of nocturnal predators; they routinely linked night with disaster. Even that word derives from the firmament: Dis = bad; Aster = star.

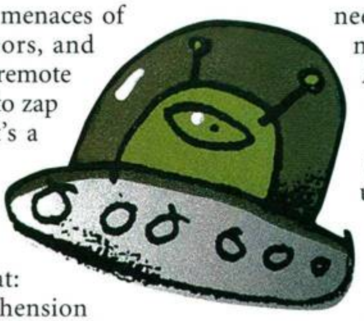
In modern times, sky-related hazards are relatively small, but the risk is neither zero, nor is it limited to sensational possibilities such as being clobbered by a meteor. (The only person known to be injured by one, E. Hullet Hodges of Sylacauga, Alabama, was not seriously hurt when she was struck on the thigh in 1954.) A more spectacular peril, vividly depicted by Hollywood movies, derives from mass extinctions. Each of us is far likelier to die from the impact of a big meteor than in an airplane crash. That's because the rare mile-wide intruders can wipe out half of Earth's life-forms while jet travel kills relatively few of us (despite airlines' best efforts with their onboard meals).

A more immediate hazard comes from muons. These subatomic particles, created when high-energy cosmic rays from deep space strike Earth's upper atmosphere, constantly zip through our bodies and occasionally damage genetic material at the cellular level. They cause many of the spontaneous tumors that have been with us long before we started downing charred hot dogs.

But the most destructive, ongoing risk factor from above is absent while we stargaze. It arrives when narcissism drives us to reckless sunbathing, exposing skin to amounts of ultraviolet light that even snakes are smart enough to avoid.

Apart from these very real celestial menaces of solar radiation, extinction-class meteors, and cancer-causing muons, there remains a remote possibility of a near-enough supernova to zap our planet with lethal gamma rays. It's a wonderfully weird catastrophe worthy of Halloween (see "When Disaster Strikes," page 46).

An amazing number of Americans imagine a truly ominous cosmic threat: Aliens. Now. In our midst. The apprehension persists, but not in the minds of astronomers, who never seem to see flying saucers despite scanning the skies more thoroughly than anyone else. A more realistic peril may exist if intelligent life-forms within 50 light-years are currently engaged in a SETI-like listening program. If they're picking up TV signals from shows such as *Wrestlemania,* they may already be en route to destroy us.



Ken Fye

The constellation Andromeda derives its name from a mythological woman who was chained to a seaside rock as the tide rolled in.

Actually, the popular notion of TV shows radiating into space complete with commercials is off the mark: The stronger and therefore more detectable of our signals are TV carrier waves (and military radar) rather than the programs themselves. Any creatures monitoring radio emissions in our vicinity would discover a cyclic order suggesting an artificial origin. This happens because Earth's rotation makes high-intensity transmission areas (such as the East Coast of the United States) alternate with quiet zones (Easter Island's longitude, for example) with an attention-grabbing periodicity in wavelengths not associated with natural phenomena. If they're nearby and smart, they probably know we're here.

Some of the sky's most seemingly supernatural phenomena are unrelated to real danger — they just *look* eerie. With solar maximum now nearly upon us, an increase in aurorae is almost certain. Seen from non-light-polluted areas of the United States and other temperate and high-latitude countries, those silent pale green or deep red undulating patterns are disconcertingly ghostly. If ever a movie producer needed a dramatic backdrop for Halloween night, he couldn't do much better. Astronomers explain those edge-of-space specters as an exquisite interplay between the sun's shotgun bursts of subatomic particles and our planet's magnetic field. But understanding the underlying physics does not diminish their eerie sensory impact.

Most other sky spectacles are beautiful rather than scary. Eclipses and bright conjunctions no longer arouse fear. Even that traditional terror-producer, the unexpected Great Comet, a ghostly specter with few peers, has stopped provoking the execution of astronomers.

November's gloom may also stem from unaccustomed cold nights and the dramatic increase in cloudiness over much of the United States. But there's more to this month's uneasy skies than chilly murkiness or low-probability perils that were unknown until this century. After all, real hazards probably spook backyard astronomers less often than unidentified animal noises. Though one unfortunate astrophysicist was indeed crushed by an observatory dome, our avocation hardly merits high insurance premiums. Instead, nocturnal disquiet may stem from a simple fear of darkness compounded by the many deep-seated legends that involve the sky. Autumn is the season most associated with such mythology. At no other time do so many bizarre Greek figures creep silently overhead, evoking tales worthy of Poe.

Modern horror films feature fast action that caters to today's reduced attention spans. But in older times, tortures were allowed to unfold with an exquisite slowness. Hanging directly over our heads these nights is a mythological woman named Andromeda who was chained helplessly to a rock while the tide came in. Today, no moviegoer would endure such a glacial tempo, yet most would admit it's a cunning and diabolical torment.

The old desert dwellers were alarmed by a strange autumn star that lost half its light every three nights. This went beyond amusing, all the way to supernatural, and they called it the "Demon Star," Algol, whose very name means The Ghoul. Algol lies in the constellation Perseus, near the zenith during these autumn nights. Even for a mythological figure, Perseus's life was anything but routine. He was an abused child (trapped in a floating trunk out at sea) and understandably grew up doing odd things, such as killing his grandfather. He slew the fearsome Medusa, whose "bad hair days" were legendary, and then carried around the severed head complete with its still-writhing snakes. Eventually he gave the squirming head to the beautiful Athena, apparently deeming it more thoughtful than a box of chocolates.

Add the Dragon, Furnace, Wolf, and a few other bizarre patterns speckling the heavens this time of year, and you can see why generations of stargazers succumb to autumn's unquiet spell.

The Pleiades' (M45) lovely appearance belies their link to the Black Sabbath and the destruction of the Minoan civilization on Crete.

Jerry Lodriguss

Sirius, rising by midnight, was considered unlucky for millennia. The heavens' brightest star was renowned for an ill-fated influence that abounds in literature from Homer to Dante. But the most ominous of all autumn patterns is the Pleiades, the Seven Sisters, now up shortly after nightfall and out all night.

In Greek mythology, the group represents the daughters of Atlas, a tranquil-enough pedigree. Seen through binoculars, they seem lovely rather than sinister as they suddenly multiply from eight (the number commonly glimpsed under dark skies) to hundreds. To Tennyson they glimmered "like a swarm of fireflies," though the pretty blue tint uncovered by the slightest optical aid makes them look more like a jewel box.

When we look at the Pleiades in another light, their benign aura vanishes, replaced by evil. Ominous legends recorded by peoples around the world show the unique little cluster deeply linked with disaster.

The dreaded Black Sabbath of the Dark Ages, which evolved to become Halloween, was celebrated on the very night the Pleiades reached its highest position at midnight. Today's trick-or-treaters perform their mischief with nary a glance upward, but their pranks are tied to the little naked-eye grouping in the east.

The Pleiades' sinister association has inspired both speculation and scholarship. William Tyler Olcott's *Field Book of the Skies*, my childhood sky-bible, suggested a link to the Atlantis myth. This may have origins in the catastrophic volcanic explosion of 1450 B.C. on the island of Santoríni (also known as Thera) in the Aegean Sea, which destroyed the Minoan civilization on nearby Crete. He speculates that the great loss of life occurred at a time of year when the Pleiades were prominent, causing them to be forever linked with calamity.

The Mayans, Aztecs, and other new-world cultures feared the Sisters as well. According to Robert Burnham, Jr., in his classic *Celestial Handbook*, the west face of the Great Pyramid of the Sun at Teotihuacán near Mexico City precisely faces the setting point of the Pleiades.

Pagan rites derived from the ancient Druids took place on the date of the Pleiades' highest yearly ascension, celebrated in the Dark Ages as the Witch's Sabbath. Modern-day Halloween is still observed on the very same night as those demonic precursors. Since then, Earth's precessional wobble has advanced the Pleiades culmination date to November 21. If you belong to one of today's lovable satanic sects, you might therefore want to wait until the 21st to perform your traditional goat sacrifice or ritual breaking of your favorite eyepiece, or whatever you need to do to appease the sinister entities of that night.

Alternatively, you can bravely forget all this eerie business and simply enjoy the season's crisp skies from any site away from lights and sky-obstructing buildings. You can't do much better than . . . a cemetery. ■

Frequent contributor Bob Berman is author of the new book Cosmic Adventure. *He wrote "Less is More" in last month's issue.*

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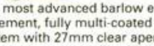

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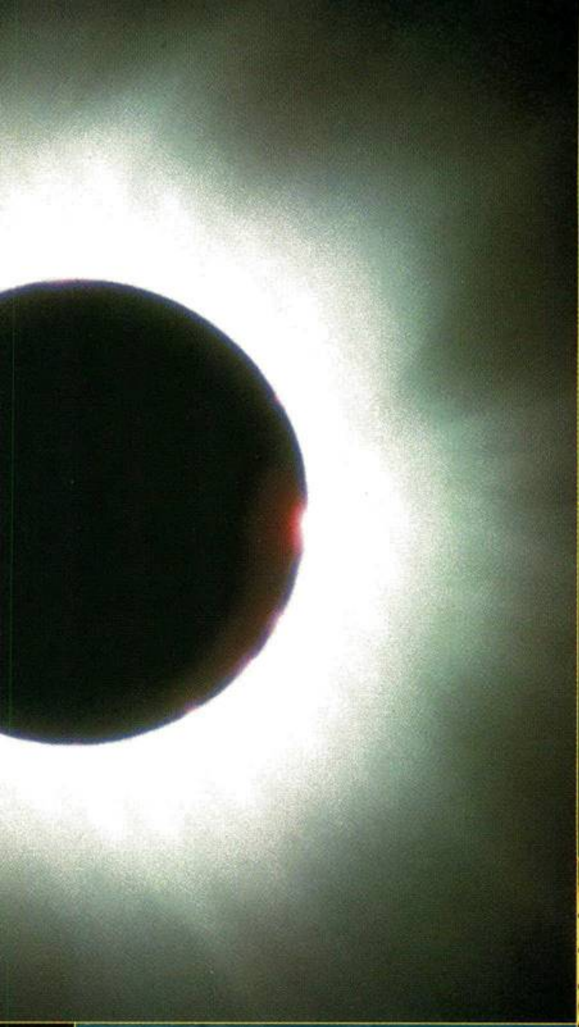
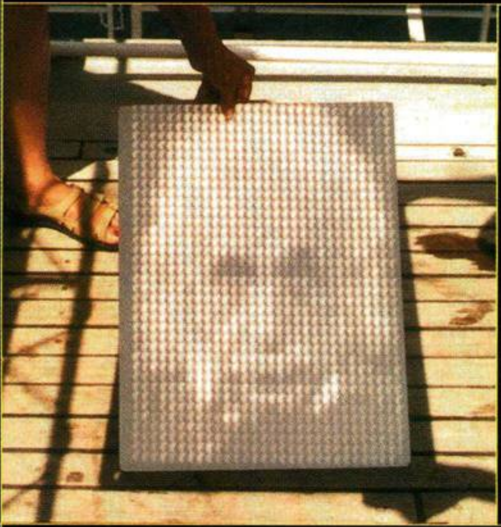
The millennium's final solar eclipse left a trail of bedazzled viewers in its shadowy wake.

As the eclipse on August 11 waned, many of the pilgrims on *Astronomy* magazine's Black Sea cruise were already gulping champagne and congratulating each other. The promised conga line had not yet formed, but these travelers had seen a perfect two-minute, 20-second total eclipse at sea. As the second flashy diamond broke through the hills of the moon, Greek music rose from all corners of the top deck. A man whispered, "I don't know how to say this, but lots of people were crying, even the men."

In much of Europe, where throngs of travelers also gathered for the false night, clouds filled the sky, clearing in some places only for a minute or so of totality. On the Black Sea, the sky behaved dutifully, entertaining us, moving even the most jaded among us: a diamond ring at beginning and end of totality; a deep, circular corona; and bright prominences flaring all the way around the blocked face of the sun.

Accept these few photos as hors d'oeuvres that must tease you until December when we will share a fuller course of stories and images.





Above: The Cornwall skies frustrated eclipse chasers. Left: Einstein's face, "painted" in the light of eclipse crescents, came onboard a Black Sea cruise ship with California artist Bob Miller. Below: Bright red prominences break away from the limb of the sun shot from Turkey during totality. Credits from top to bottom: David J. Eicher, Dave Buchla, Andrew W. Steinbrecher.

Top: At totality, the sun, shot from Lake Hayar, Turkey, displayed a wonderfully round corona. Above left: By the time the first diamond ring appeared above the Black Sea, Venus also shone brightly. Above: More than one eclipse chaser watched afloat in a pool on a ship in the Black Sea. Left: Black Sea eclipse crowd gathers for first contact. Credits clockwise from left: Bonnie Britton, Peter Sutter, Andrew W. Steinbrecher, and Mary Byrne.

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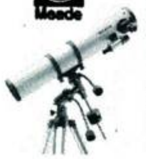

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3.5" to 4"	79.00	N/A	59.00	N/A
4.25" to 5"	99.00	N/A	69.00	N/A
6"	109.00	$ 79.00	$ 79.00	$ 69.00
7" to 8"	129.00	89.00	89.00	79.00
10"	149.00	109.00	N/A	89.00
11"	159.00	119.00	N/A	99.00
12" to 13.1"	179.00	139.00	N/A	119.00
14"	199.00	149.00	N/A	139.00
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Zoom	52x-156x	220

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20mm		97
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New! ETX-125/EC

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Ac adapter 110 volt #541	x	x		40
Case- hard #774	x			100
Case- hard #775		x		150
Case- soft #765	x		x	42
Car cord 12 volt #607	x	x		28
Electric focuser #1244	x		x	120
Electric focuser #1247		x		120
Finderscope 8x25 right-angle #825	x		x	52
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Interface cord #505	x	x		26
Low-latitude weight #1422	x			30
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Tripod- table leg set/4 #881		x		55
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Fits 90mm ETX's

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$195

125mm
$call

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Weighs just 8 lbs. Adjusts 27-70". Anodized aluminum.

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$32 Fits onto visual back (at right). Shorty design. Only 3" long.

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$33 125mm

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By the Light of the

A video camera captures Luna digitally during fleeting moments of sharp seeing.

I am still hooked on the moon's rugged surface 35 years after I first looked through a boyhood friend's department-store refractor, but capturing lunar craters on film can be exasperating. Earth's turbulent atmosphere always seems to blur the images. However, I learned how to capture unbelievably sharp lunar close-ups with an inexpensive video camera attached to my telescope during random moments of atmospheric calmness — moments that astronomer Percival Lowell called "revelation peeps."

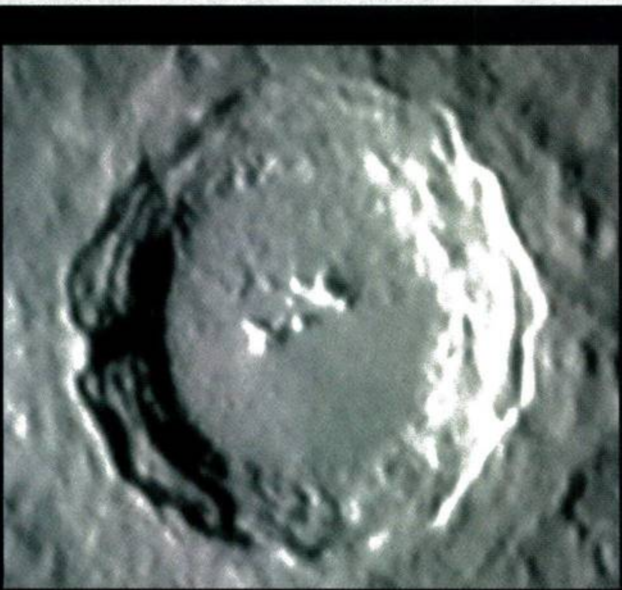
Film and a traditional 35mm camera didn't work nearly as well: The more I enlarged a lunar image, the dimmer it became, which forced me to take longer exposures or use faster, grainier films. Either way, the pictures were too blurry. It was a vicious circle.

The problem was that film is inherently inefficient: For every 100 photons of light that strike a piece of film, only two to four produce the grains of metallic silver that form an image. Physicists call this a "detector quantum efficiency" of 2 to 4 percent. A third to a half of the photons that strikes the video camera's charge-coupled device (CCD) silicon chip is converted into an electrical signal.

Several years ago I purchased a closed-circuit black-and-white video camera. Weighing in at less than 8 ounces, it's no bigger than a cellular telephone. Units that sold for several thousand dollars a decade ago are now as low as $200.

My camera's CCD array is only 6.4 by 4.8 mm, divided into 640 columns and 480 rows of minute picture elements, or "pixels." Surprisingly, this little chip generates huge, sharp images on a television monitor. The electronic shutter in my video camera limits exposures to 1/60 of a second or less. The monitor displays the frames so fast it generates a movie.

Now, I effortlessly catch the fleeting moments of superb seeing, along with the long intervals of blurry images — a few grains of wheat diluted from a mountain of chaff. This is the chief advantage of video. A two-hour videocassette that costs a few dollars can hold 216,000 images.



The crater Copernicus, formed more than 1 billion years ago, is not far from the center of the lunar disk. Its terraced inner walls rise more than 12,300 feet (3,750 m) above the interior floor, which includes a complex pattern of prominent peaks.

The Hubble Space Telescope resolved features as small as 280 feet (85 m) across in this close-up of Copernicus's terraced walls and material blasted out by the impact.

John Caldwell (York University), Alex Storrs (STScI), and NASA

Moon

Text and Photos by Thomas Dobbins

I can capture crevasses in the rilles near the crater Triesnecker that are less than 2,300 feet (700 m) wide. That is not as good as the Hubble Space Telescope, which can resolve lunar features as small as 280 feet across, but my camera is in my price range.

Unlike bulkier camcorders, these little cameras are not equipped with integral videocassette recorders and must be connected to a separate, stand-alone videocassette recorder by a cable. I display my camera's real-time video on a 13-inch black-and-white television. The breathtaking sight of a large lunar crater such as Copernicus almost filling the screen is not soon forgotten. I can usually see lunar details that elude me when I look through the telescope. On most nights, I abandon my perch at the eyepiece of my 14-inch Schmidt-Cassegrain without regret. I slide the video camera into the focuser barrel, sit back, and watch in comfort. When visitors drop by, I point out lunar features on the screen.

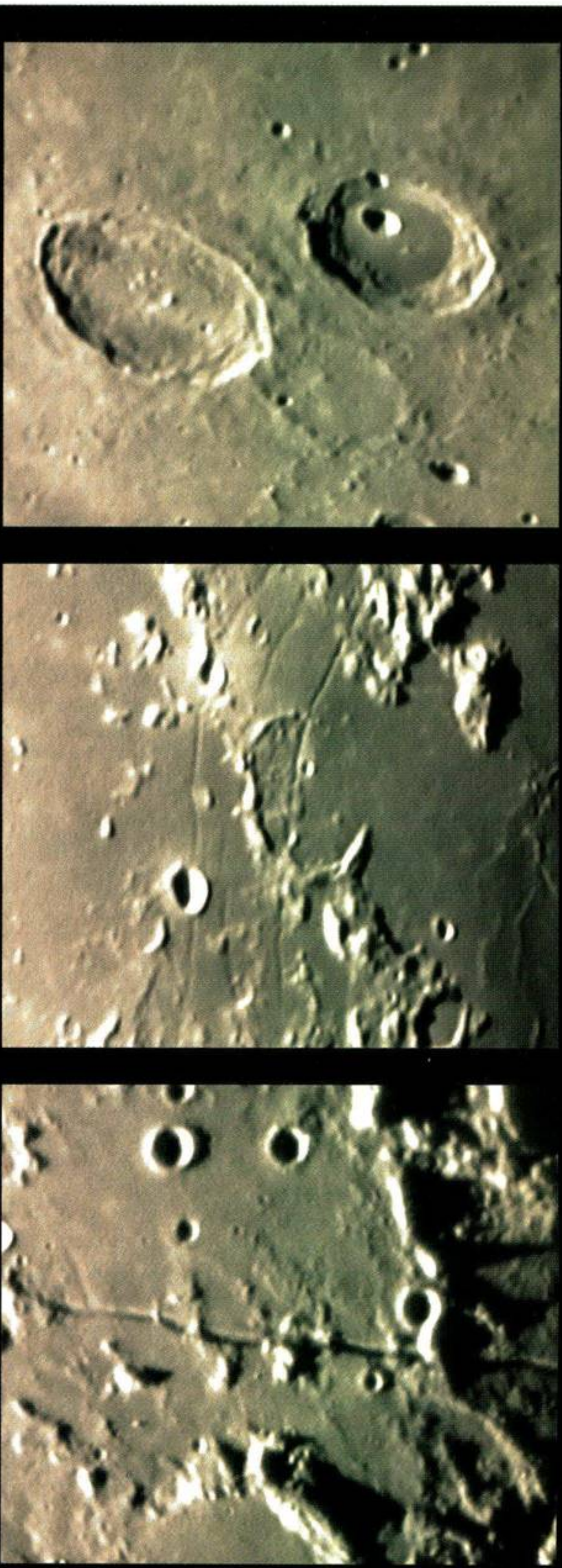
To extract "hard copy" images, I review a videotape to locate the very small number of frames that are exquisitely sharp. Reviewing videotapes can be tedious and time consuming, so I do it on cloudy nights. All this has prompted my wife to suspect that I'm mildly but harmlessly demented.

A cable feeds the output of the VCR to a "frame grabber" board installed in my IBM-486 personal computer. The frame grabber converts the analog video signal to a digital format that can be captured and stored in the PC's memory. Digitizing a black-and-white video frame assigns numerical values to the location and brightness of each pixel. Once the video frame is digitized, I use image processing software to reduce the prominence of the checkerboard pattern of pixels that make up the image. I can also accentuate the visibility of subtle details and tweak the brightness and contrast.

With a few clicks of the mouse and at a cost of less than a dime for a sheet of premium coated glossy paper, a high-resolution laser printer delivers prints of excellent clarity. No camera. No film. No darkroom. I do all the image processing at my desktop.

I am rewarded for a modest investment in equipment and an immodest amount of patience. Images obtained this way rival the most detailed pictures of the lunar surface ever obtained by many other methods.

Thomas Dobbins, a research chemist and avid amateur astronomer, is coauthor of Observing and Photographing the Solar System.



Top: The floor of the 55-mile (90-km) crater Atlas (left) is crisscrossed by delicate fissures.
Middle: A spectacular set of parallel rilles arcs along the "shoreline" of Mare Humorum, the Sea of Moisture.
Bottom: The smallest craterlets in this image of the Ariadaeus Rille are less than 1,950 feet (600 m) in diameter.

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*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing and shipping charge to the price. Slightly lower P&S for payment by check. Lumicon showroom prices are $50 to $100 higher.

See the Meade ad in this magazine for full descriptions. Starfinders are complete telescope systems with motor drive and finderscope (Equatorial only) and 25mm (48x) eyepiece. New DC motor runs on four AA batteries.

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ACCESSORIES

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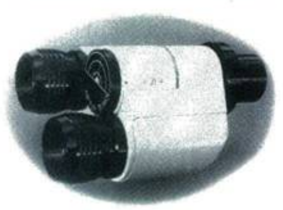
New LUMICON® binocular viewer



The new LUMICON Binocular viewer is judged to be equal or superior to even more expensive binoviewers. Custom made for Lumicon , these exquisite German-made units have the highest image transmission (91%) Threaded for filters. Both planetary and deep-sky viewers will be impressed. **SALE PRICE 'til Dec. 31 $649.00**

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LX50 – includes dec. motor, hand controller.
LX 200 - full computer control w/64k mem.
Tripod: Extra for LX 50; included for LX200

Note: Wedge is not needed for visual observing with the LX 200. Select f/10 or f/6.3 (no extra charge) for LX 200.

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Prominence
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Lumicon Solar Prominence Filter 1 1/2 Angstrom bandpass. Includes 77mm energy rejection pre-filter.

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15mm Panoptic 1 1/4", 68° field	$210
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Note: TeleVue warranty may not be valid outside USA

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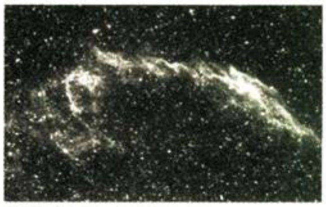

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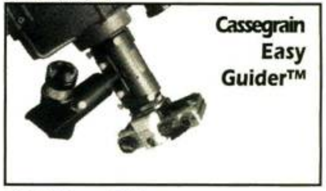

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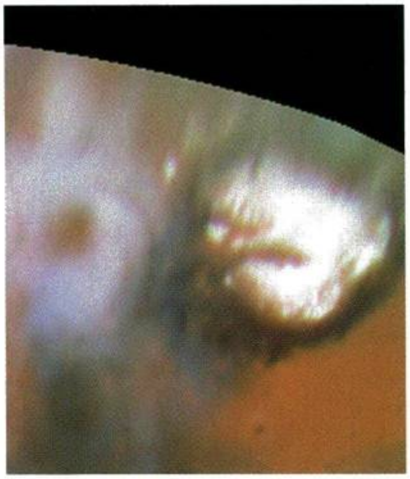
Storms on Mars, White Dwarfs, Expanding Universe



On April 27, 1999, the Hubble Space Telescope imaged a 1,000-mile-wide storm (left) near Mars's north polar cap (right).

Jim Bell (Cornell University), et al., and NASA

Q: I read recently that a hurricane-like storm was spotted on Mars close to the north pole. It contained water ice. Did this large storm create snow or hail? And could a storm like this closer to the equator produce rain and be partly responsible for the water-like erosion seen on the surface? — *Hunter Mortley, Albuquerque, New Mexico*

A: The large cyclonic storm system spotted by the Hubble Space Telescope in late April was indeed composed of water ice clouds. In its size and shape it looked a lot like some hurricanes on Earth, but it was not at all what meteorologists would call a hurricane.

Storms on Mars can be relatively common and easy to see (all you need is a good telescope and a blue filter), but unlike those on Earth, they contain very little water. Mars has only a tiny amount of water vapor in its atmosphere, but clouds can still condense if the air cools slightly (from rising motion, for example). The clouds can rapidly sublime directly back into water vapor when the air warms again (from sinking motion, perhaps).

At the very low pressures and cold temperatures of today's martian atmosphere, water cannot exist in liquid form, so it cannot rain or hail. However, in the distant martian past, temperatures and pressures may have been higher, and so rainfall may have been possible and may have helped form some of the winding channels still seen from orbit today. This is highly controversial, however, and one of the goals of NASA's current Mars missions is to answer these types of climate questions (see "Divining on Mars," February 1999).

Even with the current thin atmosphere, though, it does snow during martian winters (it's really the same process that forms clouds, just that it occurs at the surface). But most of the snow is carbon dioxide ice (also known as dry ice) rather than water ice, making traditional winter pursuits such as skiing, sledding, and snowball fights impossible. — *Jim Bell, Cornell University*

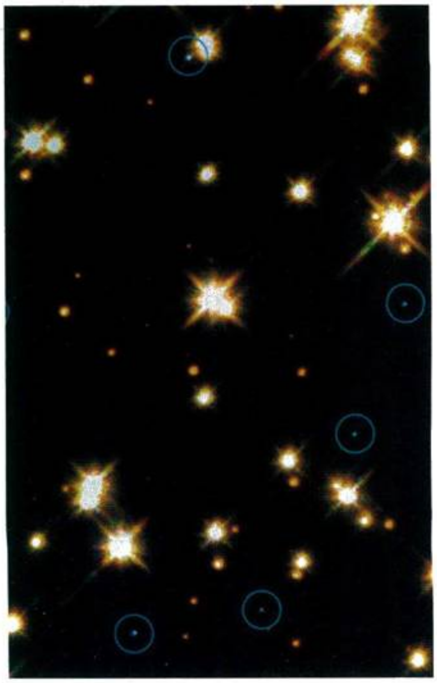
Q: What happens to a white dwarf when it finally uses up all its fuel? — *David Campbell, Sydney, Australia*

A: The simple answer is that the star simply cools and fades.

Most white dwarfs form from the cores of evolved giant stars. As they emerge from their cocoons, white dwarfs are extremely hot. This heat energy was originally deposited within the star during prior evolutionary stages. The newest and hottest white dwarfs have surface temperatures well in excess of 100,000 kelvins (180,000° F) — more than 10 times hotter than the sun. Such new white dwarfs are the hottest "normal" stars that we know about. They quickly exhaust their remaining nuclear fuel and begin cooling for the rest of time.

As white dwarfs cool, they also fade in brightness. The reason we can see them is that their heat energy takes a very long time to escape. White dwarfs are like glowing embers removed from a fire, slowly cooling and fading.

Like an ordinary object such as a brick, a white dwarf cools fastest when it's hottest. Early in its white dwarf phase, the star's temperature decreases by a factor of two every 100,000 years or so. As it cools further, the time it takes for the temperature to drop by a factor of two gets longer and longer. It takes an average white dwarf 10 million years to cool down to 30,000 kelvins, the temperature of the hottest main sequence stars. At this point, the time it takes for the white dwarf's temperature to drop by another factor of two lengthens to 25 million years. At 500 million years, when the star has cooled to 10,000 kelvins, this cooling time is 1 billion years.



The circled stars in this Hubble Space Telescope image of globular cluster M4 are white dwarfs that are slowly cooling and fading.

Harvey Richer (University of British Columbia) and NASA

Extending this simple idea brings up another interesting aspect of white dwarfs: The coolest ones have ages (and cooling times) that are comparable to the age of the universe. They have temperatures of 3000 kelvins or so, which means they are around 10 billion years old. The lack of even cooler white dwarfs is strong testimony for the finite age of our universe. Careful comparison of white dwarf cooling models with the observed numbers of cool white dwarfs provides a precise measurement of the length of time that star formation has been going on in our part of the galaxy — an age that is in excellent agreement with cosmological measurements.

Within the white dwarfs themselves, a remarkable transformation occurs when they cool below about 6000 kelvins — the temperature of the sun. At those relatively low temperatures, the material within the stars begins to crystallize. Remember that the densities within white dwarfs are immense — 1,000 kilograms per cubic centimeter — the equivalent of compressing the New York Yankees' starting lineup into a teaspoon. Under those conditions, when the temperatures drop, the matter within the star solidifies, rendering much of the stellar interior crystalline. Because a significant fraction of the interior's matter is carbon, one could loosely say that the star becomes a "diamond in the sky" . . . a cooling gem. — *Steve Kawaler, Iowa State University*

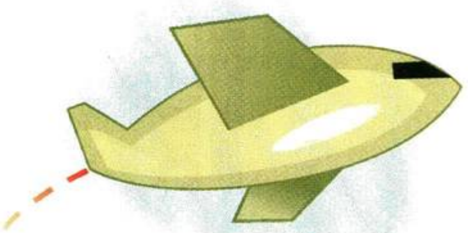
Q: What star catalogs provide star distances along with the object's position? — *Scott Robinson, Houston, Texas*

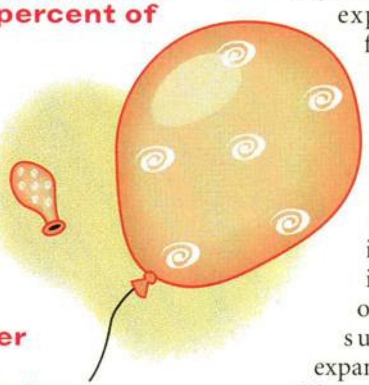
A: Tables listing distances (among other data) for bright and nearby stars are readily available in *The Observer's Handbook*, published each year by the Royal Astronomical Society of Canada. Distances for many thousands of stars, bright and faint, can be found in volume 1 of *Sky Catalogue 2000.0*.
— *David J. Eicher, managing editor*

Q: In our expanding universe, galaxies are moving away from one another such that the more distant the galaxy, the greater the recessional velocity. The most distant galaxies observed so far are receding at 70 to 80 percent of the speed of light. According to Einstein's special theory of relativity, mass increases with velocity. Thus, the greater the recessional velocity, the greater the relativistic mass. Because this process requires an input of energy, where does the energy come from? — *John Wojtowicz, Goodyear, Arizona*

A: This is a good question that highlights a common misconception about the expanding universe. As Mr. Wojtowicz correctly points out, Einstein's special theory of relativity stipulates that objects containing mass moving *through* space increase in mass as their velocities increase, and this effect becomes particularly important when velocities approach the speed of light. But that's not an accurate characterization of the universe's expansion. In cosmic expansion, space (or more accurately, spacetime) *itself* is expanding. Galaxies ride the wave of cosmic expansion — they are carried away and apart from one another by the expansion of spacetime. Because galaxies are not traveling *through* space like rockets traveling between Earth and Mars, the expansion of the universe does not increase galaxies' masses, so there's no need for any additional input of energy.

Interestingly, the special theory of relativity does not rule out the possibility that spacetime itself can expand, in essence, faster than the speed of light. In other words, the universe can expand so fast that the distance between two points increases faster than the speed of light. Many cosmologists believe that the universe experienced this kind of faster-than-light expansion during a fleeting moment of time immediately after the Big Bang — the so-called inflationary epoch. If cosmic expansion is indeed accelerating, as indicated by recent observations of type Ia supernovae, then the expansion rate of the universe will exceed the speed of light yet again — perhaps within 10 billion years. — *Robert Naeye, associate editor*





Galaxies do not travel through space as the universe expands, like an airplane traveling from New York to Los Angeles (left). Instead, galaxies are carried apart from one another by the expansion of the universe, just as painted spiral galaxies on the surface of a balloon move farther apart as a balloon expands (below). *Astronomy*: Terri Field

The following institutions are assisting *Astronomy* in an effort to answer all questions submitted to Ask Astro (you can e-mail your questions to askastro@astronomy.com). *Astronomy* thanks Edward Gleason of the Southworth Planetarium for organizing this effort.

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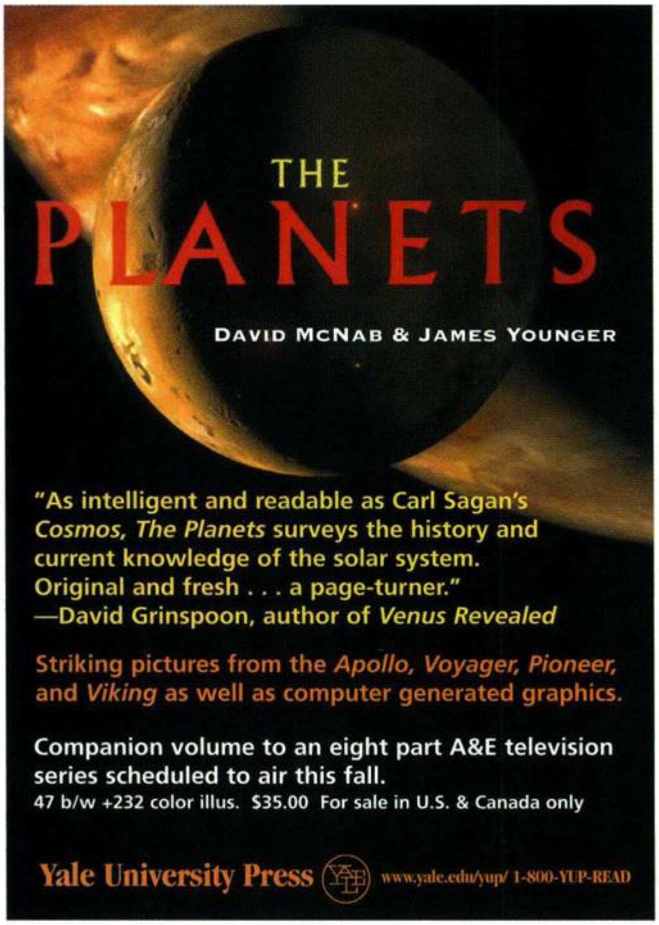

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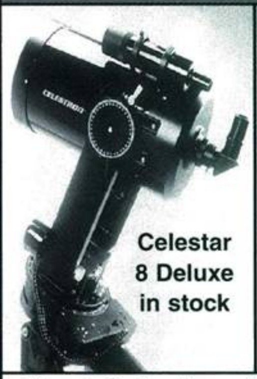

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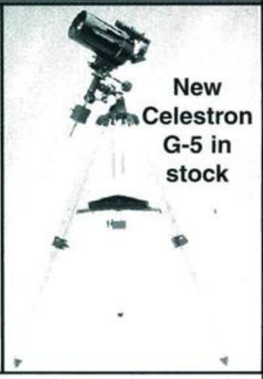

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Nikon Sport Optics, 1300 Walt Whitman Road, Melville, NY 117417-3064; phone, (800) 247-3464; website, http://www.nikonusa.com. Nikon 7x50 OceanPro Binoculars without compass: *$316.95*, Nikon 7x50 OceanPro Binoculars with compass: *$406.95*.

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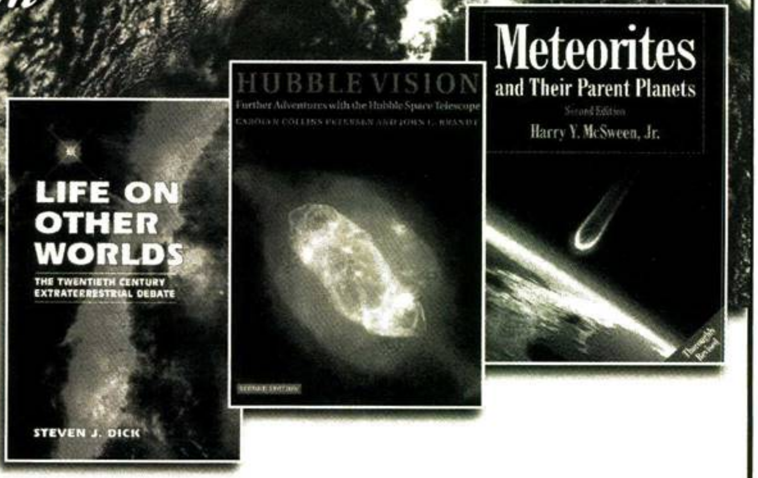
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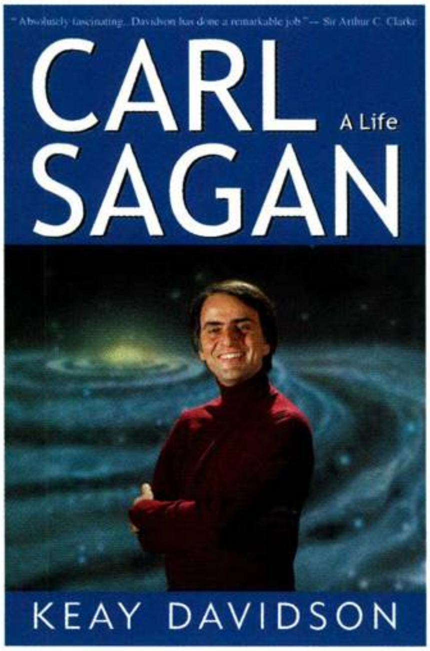
BOOKS

Carl Sagan: A Life

Keay Davidson, 512 pages, John Wiley & Sons, Inc., New York, 1999; ISBN 0-4712-5286-7; hardcover, $30.

Carl Sagan: A Life in the Cosmos

William Poundstone, 560 pages, Henry Holt and Company, New York, 1999; ISBN 0-8050-5766-8; hardcover, $30.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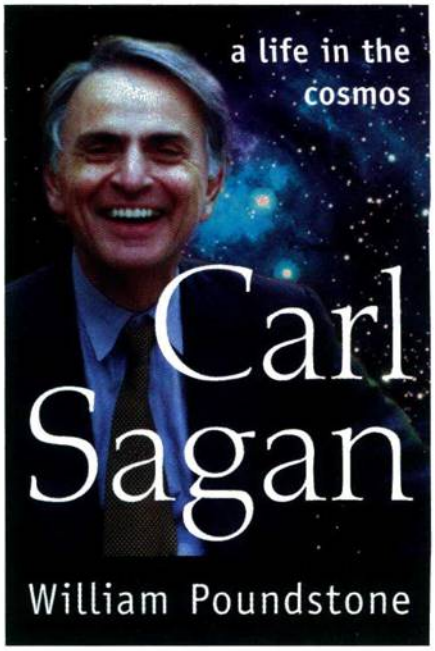
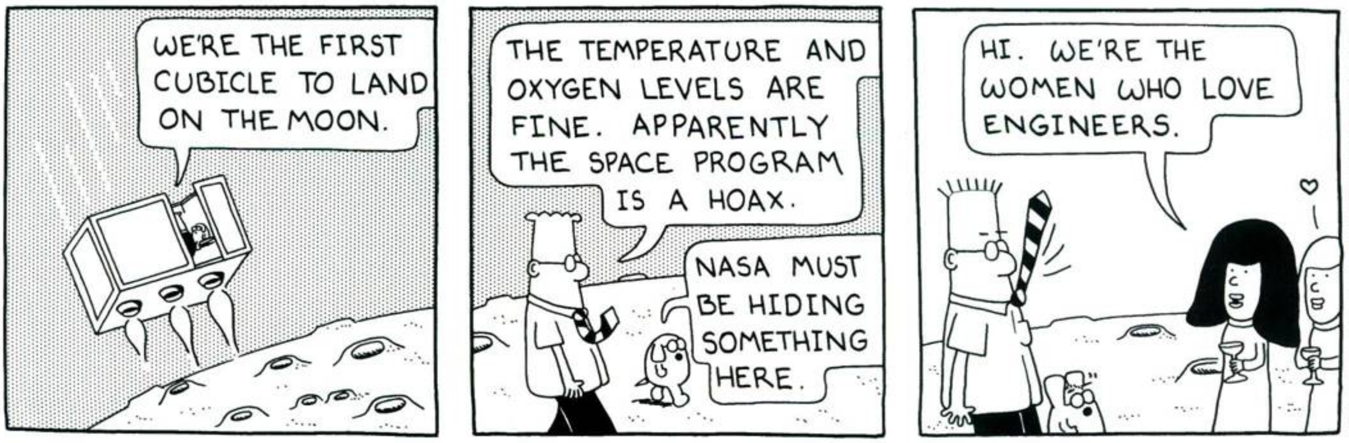

a life in the cosmos
Carl Sagan
William Poundstone

▶ I can still remember where I was and what I was doing the moment I heard that Carl Sagan had passed away. Like many, I was a fan of his astronomical ideas and ramblings, so I was deeply saddened by the loss of a man who could bring the heavens down to Earth and put stars in the eyes of so many.

Two Sagan biographies by noted science writers are just hitting the bookstores, *Carl Sagan: A Life*, by Keay Davidson and *Carl Sagan: A Life in the Cosmos*, by William Poundstone. Despite the similarity in subject matter, there is not a great deal of overlapping material in the two books. Davidson spends more time on items such as the Mariner 2 mission (see "Carl Sagan Comes of Age," page 40), marijuana usage (yes, he did inhale), and the *Cosmos* TV series, while Poundstone dwells longer on the Green Bank and Byurakan conferences on extraterrestrial intelligent life and biology experiments on the Viking missions to Mars.

Those who idolized Sagan will probably prefer Poundstone's book for its more positive portrayal. The biography begins like an adventure novel, with his grandfather committing murder and escaping to the New World. However, it was his mother more than any other relative who profoundly influenced, positively and negatively, Sagan's life. A loving but overbearing mother, Rachel was sometimes mentally unbalanced. In an ironic passage, Poundstone notes, "Lynn [Sagan's first wife] told Rachel that her mother, Leone, had suffered a nervous breakdown. Rachel threw a tantrum at this news. She ran up to her room, closed the door, and cried, lamenting that her future grandchildren might inherit the taint of an unstable temperament."

Poundstone delves into the personalities of the people with whom Sagan surrounded himself, including tales of his marriages and friendships that often ended in irreconcilable differences. His friends included astrophysicist I. S. Shklovskii, biologist Joshua Lederberg, geneticist Hermann Muller, psychiatrist Lester Grinspoon, and radio astronomer Frank Drake. All were interested in the search for life beyond Earth. This quest dominated Sagan's career: the conferences on extraterrestrial intelligence, the biological studies of Mars's surface, the Pioneer plaque, and the Voyager videodisc. As it says in the foreword, "Sagan desperately wants to find life someplace, anyplace — on Mars, on Titan, in the solar system or outside of it. In all the divergent things he does, that is the unifying thread."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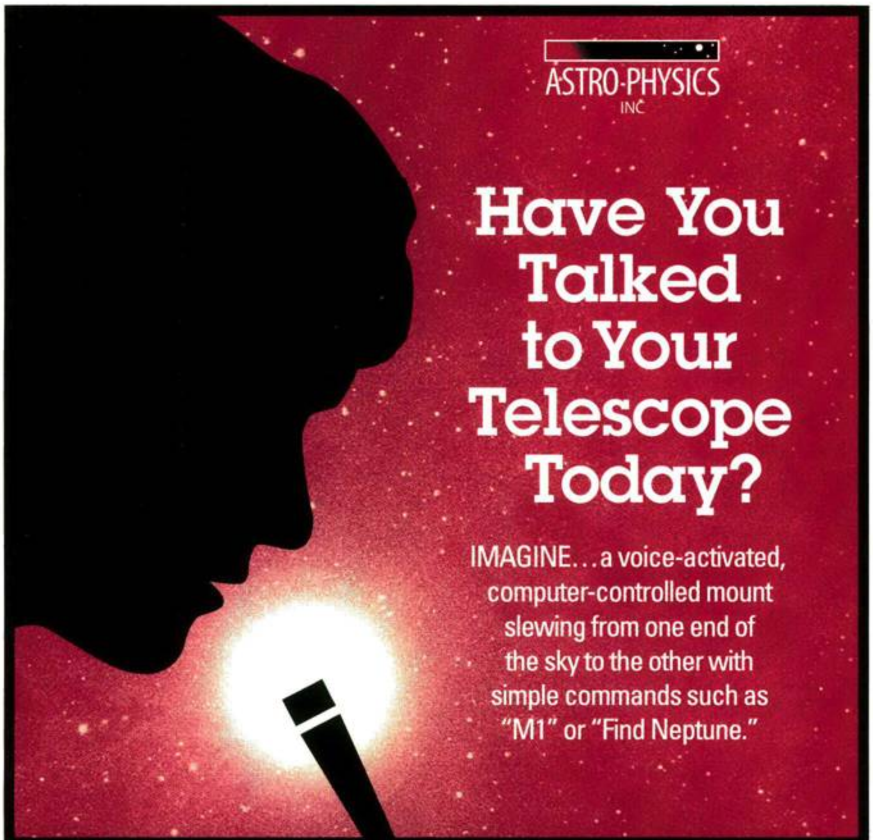

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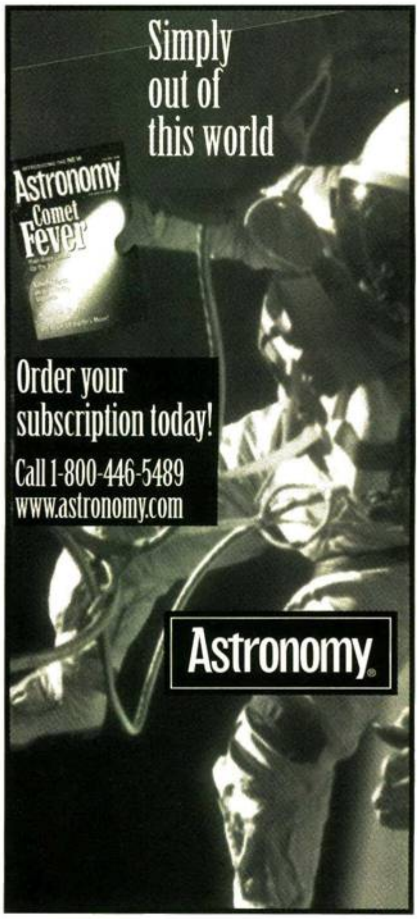

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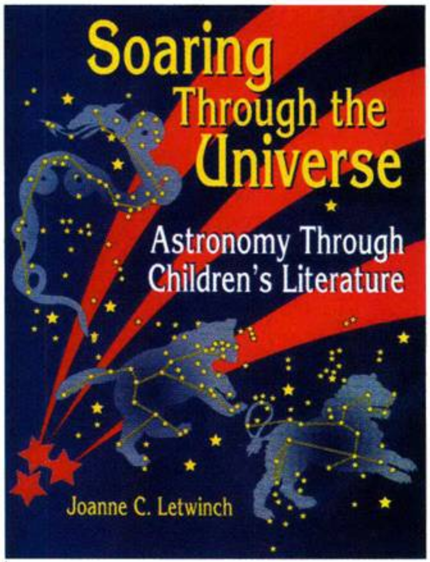
Depending on whether you loved or hated Sagan, Davidson's biography will either open your eyes or confirm your deepest suspicions. Davidson takes a more direct approach toward his subject, exposing a man many of us never knew. There is a profusion of quotations from those who were intimate with Sagan, maybe too many, giving the book a less-than-smooth flow.

Davidson shows us how Sagan's youth was characteristic of his later life: making friends with people in high places, giving polished, off-the-cuff talks, and developing ideas of extraterrestrial life. His early roles as husband and father were definitely not as polished. He was frequently neglectful and childish in his demands and expectations, no doubt a consequence of his upbringing. He clearly sacrificed his family in exchange for fame. But we are also able to watch him mature, especially with the aid of his third wife, Ann Druyan. She even manages to win over his mother and temporarily pull his head out of the stars to protest the nuclear arms race.

Sagan's many popular books receive liberal discussion, and *The Dragons of Eden* has its own chapter. Davidson believes that "*Dragons* was obviously written under the inspiration of marijuana." It won the 1978 Pulitzer Prize, which only catapulted Sagan to even greater fame. But Cosmos was probably the biggest factor in making him a household name, even while it alienated him forever from some of his fellow scientists and organizations such as the National Academy of Sciences.

Both books are long and follow a generally chronological path of Sagan's life, although Davidson's occasionally jumps back and forth in time and between Sagan's professional and personal life. Ultimately, the separate paths that the books take bring us to a similar conclusion. Carl Sagan was a man of contradictions. He firmly believed in extraterrestrial intelligent life but derided others' beliefs in UFOs and the supernatural. He was a staunch supporter of women's rights but felt his wives' duties were to support him and attend to all household and child care responsibilities. He was loved by the public for his wild ideas and willingness to speak his mind, and he was hated by colleagues for his wild ideas and willingness to speak his mind.

In the end, he was simply human, driven by dreams and lofty goals but always a victim of human fallibility. But as one-time friend Gentry Lee says in *A Life*, "Carl probably touched more hearts and minds than any scientist in history. I would guess that more people decided to pursue scientific careers because of him than any person in history. For all these things the world should be eternally grateful." — *Kelly Whitt*



Soaring Through the Universe

Joan C. Letwinch, 191 pages, Teacher Ideas Press, Englewood, CO, 1999; ISBN 1-56308-506-7; softcover, $23.

▶ Add a pinch of myth and a dollop of legend, then stir in a helping of space science and exploration and you have *Soaring Through the Universe: Astronomy Through Children's Literature.* Chapters include the moon, sun, planets, stars, and space travel. Each chapter includes lesson plans with reproducible worksheets, an annotated bibliography, and references and resources that include musical and electronic resources.

Though written for educators in grades three through six, *Soaring* will also benefit those who teach outside this age range. The lessons can be adapted to a wide variety of classroom settings.

BYTES

Pathfinder and the Best of Mars

▶ The last thirty years have brought a small armada of spacecraft to peek beneath the veil of martian mystery. There are the Mariners, Vikings, Pathfinder, and Sojourner. Even the Hubble Space Telescope has photographed the fourth planet from the sun. The next spacecraft scheduled to land on the planet's surface will be NASA's Mars Polar Lander on December 3, 1999.

In preparation for public presentations about this landing, I sampled an image library from Finley-Holiday titled *Pathfinder and the Best of Mars.* The compilation features images from the Pathfinder, Hubble, Mariner, and Viking missions to Mars and holds 31 video clips, 133 color images, and 22 stereo 3-D images in TIFF and BMP formats.

Though the disk is labeled "middle school and up," it is not directly an educational CD. Instead, *Pathfinder and the Best of Mars* is more of a reference or resource. Highlights include a satellite overview of Mars's south pole, a pan of the Carl Sagan Memorial Station, a close view of meteorite ALH84001, a partially terraformed Mars, a movie of Sojourner rolling, and a 3-D view of the Twin Peaks.

The high-resolution Pathfinder images are generated from Jet Propulsion Laboratory's originals. Other Mars images have been scanned with Kodak's Digital Science Photo CD technology. The overall result is not just gorgeous, but also handy. The file formats can easily be converted and used in multimedia programs, websites, handouts, brochures, publishing and paint application, or in any program that can read TIFF or BMP formats. Best of all, the images are public domain, so they are royalty free.

Pathfinder and the Best of Mars also comes bundled with easy-to-use software. The Kudo Catalogue Reader 3.1 is an image catalog that organizes the files using thumbnails. The thumbnails offer a visual reference

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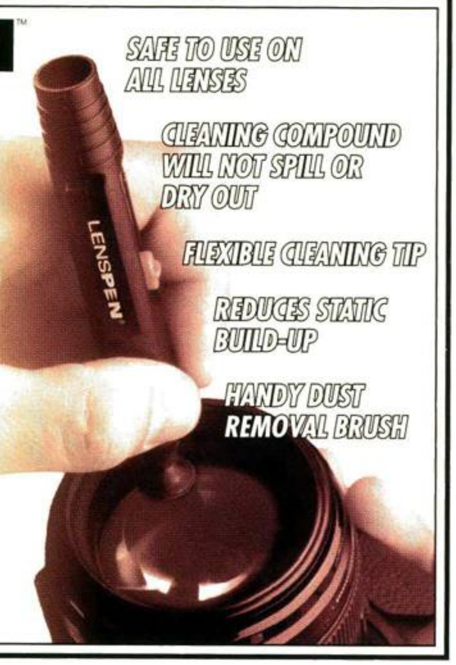

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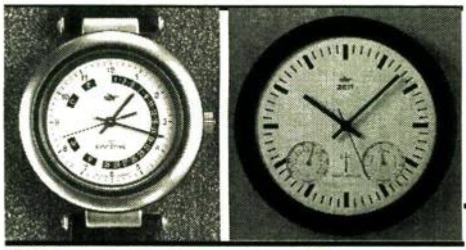

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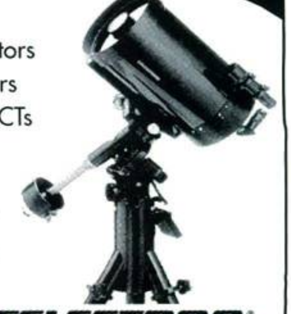
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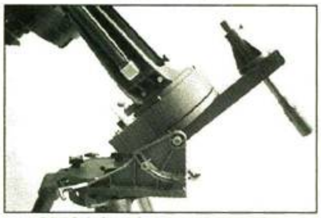
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for each image file, including Kodak Photo CD pictures and QuickTime movies. Kudo also adds additional information such as captions, the original image's file name, location, size, and file type.

The program's search capabilities are also user friendly. If you seek an image of a martian sunset, Kudo sorts the files that reflect your search parameters and displays their thumbnails. This allows the user to see exactly what each image looks like without having to open large image files. The software also includes a Riffle Control that allows a quick zoom through the catalog until you see the image you want. Once found, the image can then be displayed with a simple menu selection. A user then simply drags and drops the image into a favorite graphics or desktop publishing application.

The final software package included on the disc is a screen saver that cycles through Mars images at a leisurely pace. When you are not hard at work (and why else would your computer screen saver be on?), this screen saver gives the mind a chance to marvel at the planet's beauty. It sounds simple, but to watch this world from a variety of vistas that include its ruddy dust plains and parched deserts to its vast volcanoes, colossal chasms, immense impacts and frosty fog, with an occasional glimpse of a lander leg or tire tracks, makes it a place I long to visit. In my opinion, *Pathfinder and the Best of Mars* may simply be "the best."
— *Erich Landstrom*

Minimum PC configuration: Windows 3.0, 95/NT, 486DX+, 8MB RAM, 2X CD-ROM drive, VGA or better display card, Windows compatible sound card.

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The Hubble Space Telescope servicing mission. Includes biographies of the crew and information on the hardware being used.

NASA Space Shuttle
http://spaceflight.nasa.gov/shuttle/future/sts-103.html

More information on the Hubble servicing mission. The site also includes links to previous servicing missions.

1999 Transit of Mercury
http://sunearth.gsfc.nasa.gov/eclipse/OH/transit99.html

Fred Espenak's article on when, where, and how to look at this rare event. The site includes tables that list both Mercury and Venus transits.

'99 Leonid MAC
http://leonid.arc.nasa.gov/

The homepage for the Multi-Instrument Aircraft Campaign to study the November 17 *Leonid Meteor Shower.*

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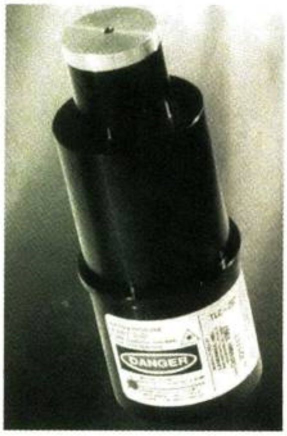

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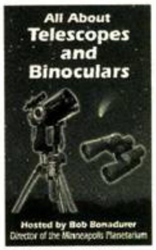

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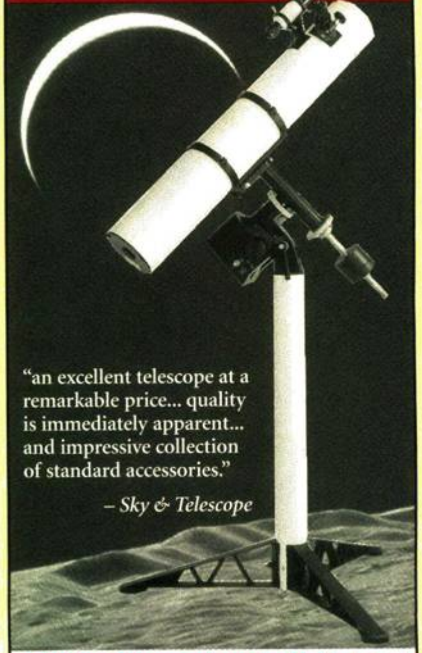

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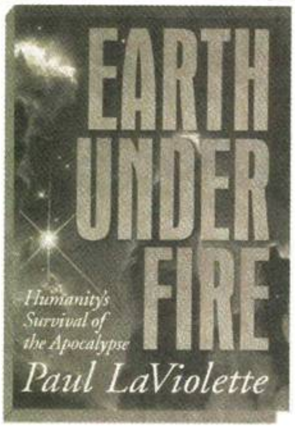

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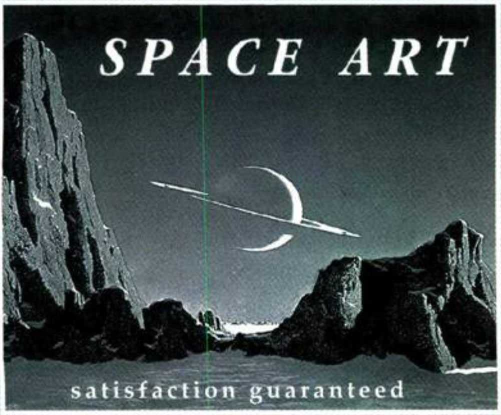

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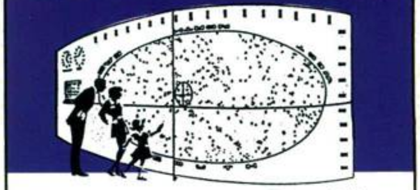

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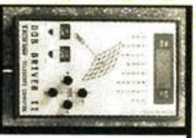

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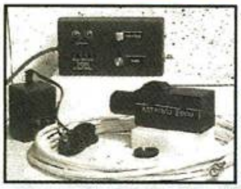

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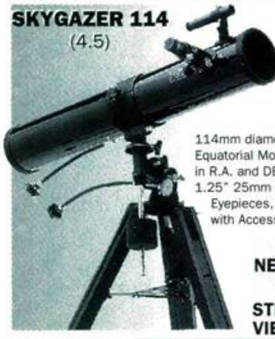

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The people at Johnson Space Center work each day to expand the boundaries of human knowledge and capabilities to meet the formidable challenge of human spaceflight. Many NASA-developed technologies continue to find wide application in the private sector.

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Inspection99 information and online registration is available at http://inspection.jsc.nasa.gov, or you can phone (281) 244–1316; e-mail, inspection@jsc.nasa.gov; or fax, (281) 483–9193.

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▶ The Montreal Museum of Fine Arts, Montreal, Quebec, Canada. For more information, contact (514) 285–2000; or view their website at, www.mbam.qc.ca/a-sommaire.html.

OCTOBER 13, NOVEMBER 17
The Silicon Valley Astronomy Lecture Series

▶ Smithwick Theater, Foothill College, Los Altos, California. Oct. 13, Geoff Marcy — Discovering Planets Around Other Stars; Nov. 17, Jill Tarter — Making Contact: The Search for Extraterrestrial Intelligence. 7 P.M. Free. Sponsored by NASA's Ames Research Center, Foothill College, the SETI Institute, and the Astronomical Society of the Pacific. Call (650) 949–7888 for more information.

OCTOBER 16
Autumn Astronomy Day

▶ Twenty-five astronomy clubs and science centers within the Astronomical Association of Northern California (AANC) celebrate a second Astronomy Day in the fall. Contact Jane Houston, e-mail, houston1@ix.netcom.com. For individual club activities, visit this website, www.lhs.berkeley.edu/SII/AANC/AstroDay.html.

OCTOBER 16
Nova Star Party and Telescope Meet

▶ Crockett Park, south of Washington, D.C. Sponsored by the Northern Virginia Astronomy Club. Contact Jeff Cook, (703) 524–5333; e-mail, jcook@cookstudios.com; website, www.cookstudios.com/nova.htm.

OCTOBER 16
Scope Out

▶ The Cincinnati Observatory Center, Cincinnati, Ohio. Sponsored by the Friends of the Observatory and the Cincinnati Astronomical Society. Contact Chuck Strubbe, 3489 Observatory Place, Cincinnati, OH 45208; (513) 321–5186; e-mail, foto@one.net; website, http://w3.one.net/~foto.

OCTOBER 20–23
Great Lakes Planetarium Association Conference

▶ Radisson Plaza Hotel, Kalamazoo, Michigan. Contact Eric Schreur, Kalamazoo Valley Museum, P.O. Box 4070, Kalamazoo, MI 49003-4070; (616) 373–7978; e-mail, eschreur@gwgate.kvcc.edu; website, www.pa.msu.edu/abrams/glpa.html.

OCTOBER 23, NOVEMBER 16
Free Public Star Party

▶ Ralph A. Worley Observatory, south of Shreveport, Louisiana. Sponsored by the Shreveport-Bossier Astronomical Society. Contact Cran Lucas, (318) 797–1524; e-mail, clucas@softdisk.com; website, www.lsus.edu/nonprofit/sbas/.

OCTOBER 28–31
Annual Meeting of the American Association of Variable Star Observers (AAVSO)

▶ Four Points Sheraton, Hyannis, Massachusetts. Contact the AAVSO, 25 Birch Street, Cambridge, MA 02138; (617) 354–0484; e-mail, aavso@aavso.org; website, http://www.aavso.org.

OCTOBER 30
Star Lecture — The Biological Universe: Tales of Many Worlds

▶ Albert Einstein Planetarium, National Air and Space Museum, Smithsonian Institution, Washington, D.C. Presented by Steven J. Dick of the Naval Observatory. 6:00 P.M. For more information, call (202) 357-2700.

NOVEMBER 4–7
Mount Magazine Star Party

▶ Mount Magazine State Park, Arkansas. Sponsored by the River Valley Stargazers. Contact Myron Barnum, 76 Observatory Lane, Dover, AR 72837; (501) 331–3773 (day); (501) 331–3620 (eve.); *e-mail*, *rvstargazer@yahoo.com*; website, http://www.geocities.com/Cape

Canaveral/Launchpad/2148/starparty.html.

NOVEMBER 5

Tidewater Regional International Dark-sky Association (IDA) Meeting/Outdoor Lighting Workshop

▶ Tidewater Community College, Virginia Beach, Virginia. For more information, send a SASE to Tidewater Regional IDA Meeting, Back Bay Amateur Astronomers, 2808 Flag Road, Chesapeake, VA 23323-2102; e-mail, glendonhowell@compuserve.com; website, http://proxima.astro.virginia.edu/~pai/VaIDA/.

NOVEMBER 6-8

Astronomy Camp for Beginning Adults

▶ Mount Lemmon and Mount Bigelow Observatories, University of Arizona, Tucson, Arizona. For more information, contact Don McCarthy, 933 North Cherry Avenue, Tucson, AZ 85721; (520) 621-4079, e-mail, dmccarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astro_camp.

DECEMBER 3-5

Planetfest '99

▶ Pasadena Convention Center, Pasadena, California. Commemorate the Mars Polar Lander touchdown, celebrate past achievements, and speculate about 21st-century discoveries. Featuring Buzz Aldrin, Bill Nye the Science Guy, astronauts Sally Ride, Shannon Lucid, Story Musgrave, and more. For more information, contact The Planetary Society, 65 North Catalina Avenue, Pasadena, CA 91106-2301; (877) 752-6387; website, http://planetary.org.

DECEMBER 11

First Conference on Light Pollution

▶ Planetario Humboldt, Parque del Este, Caracas, Venezuela. How to prevent, investigate, and control light pollution. Contact Juan Jose Downes, 582-2349188; e-mail, contaminacionluminica@yahoo.com.

CONTACT

Please submit club announcements four months in advance to Looking Ahead, *Astronomy*, P.O. Box 1612, Waukesha, WI 53187-1612, or to tconley@astronomy.com. Look for additional events at http://www.astronomy.com.

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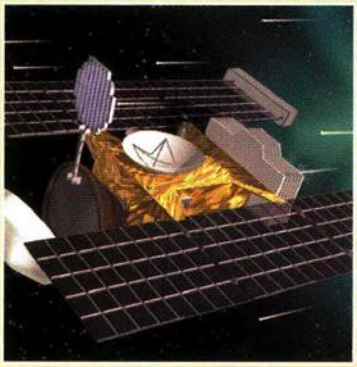

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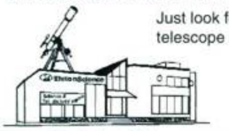

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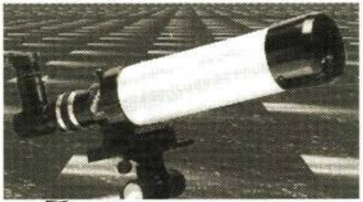

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LEONIDS

Fireballs Light Up Kansas

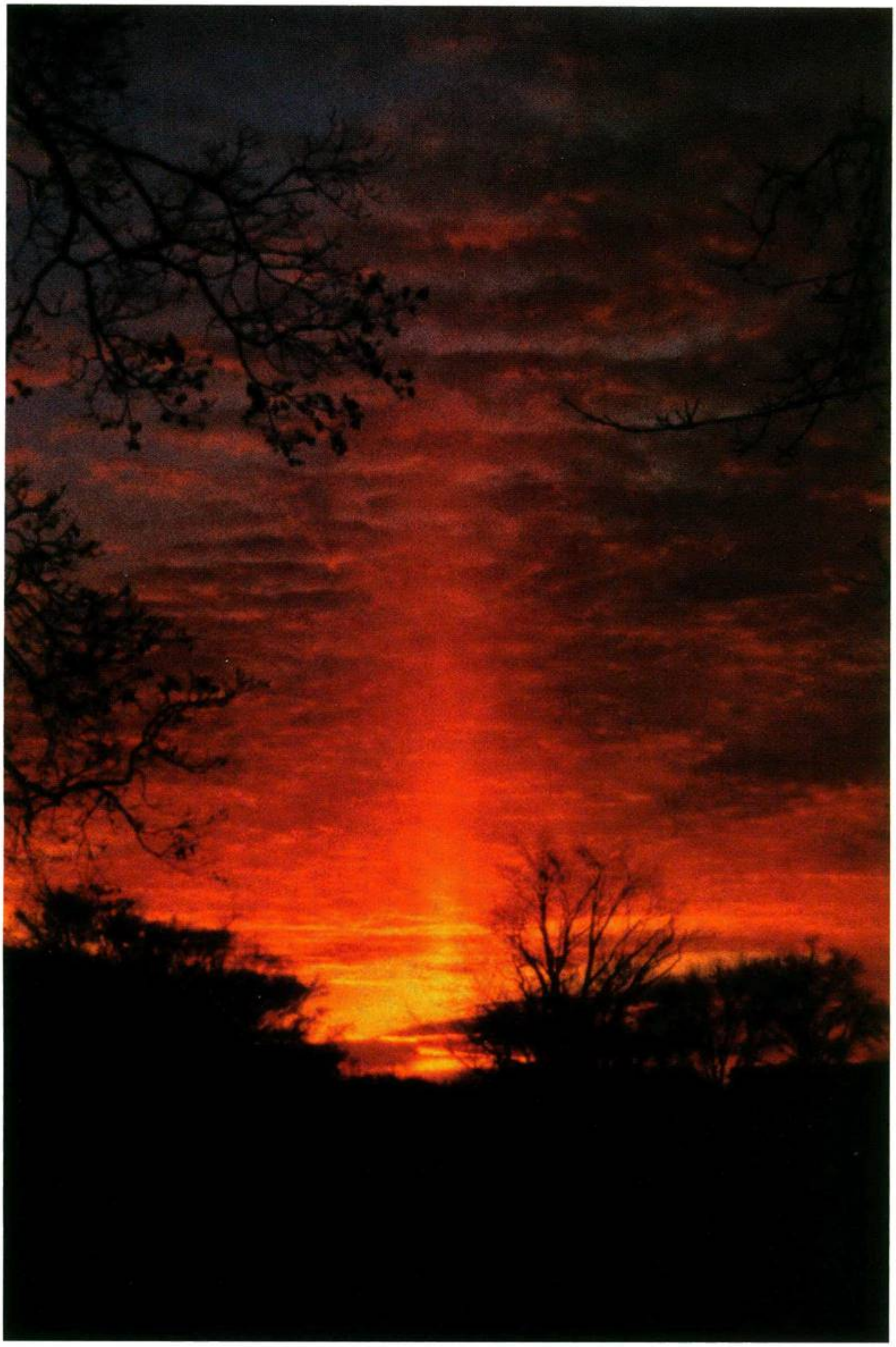
The 1998 Leonid meteor shower put on a dazzling show for those lucky enough to view at the right time.

▶ I began watching last year's Leonids a few nights before the predicted peak. I knew the show would be good because I had seen so many meteors on these preceding nights. Also, new moon, the phase of the lunar cycle that would coincide with the storm, brings a wonderful black backdrop for meteors.

During the day on Monday, November 16, I was discussing the shower (or possible storm) with the professors in the Department of Physics and Astronomy at Washburn University of Topeka where I work. I decided that if skies were clear I would go out very early on Tuesday morning and take a look.

After a long day fielding questions about the Leonids and talking with the media, I set the alarm for 4:30 A.M. and went to bed. I was just too tired to stay up all night, or so I thought. . . . Sometime around 12:30 A.M. I woke up and looked out my window, which faces south. Even with sleepy eyes, two panes of glass, and a not-quite-awake mind, I saw meteors. I believe a bright flash was what woke me.

I didn't think I could still move as fast as I did that night. I jumped out of bed, dressed, and woke my husband, Mike. I was awestruck



Sun Pillar

HARRY ORLIND

(Instamatic 110 camera, 200 ISO film, taken January 2, 1999) when I walked out the door into the night.

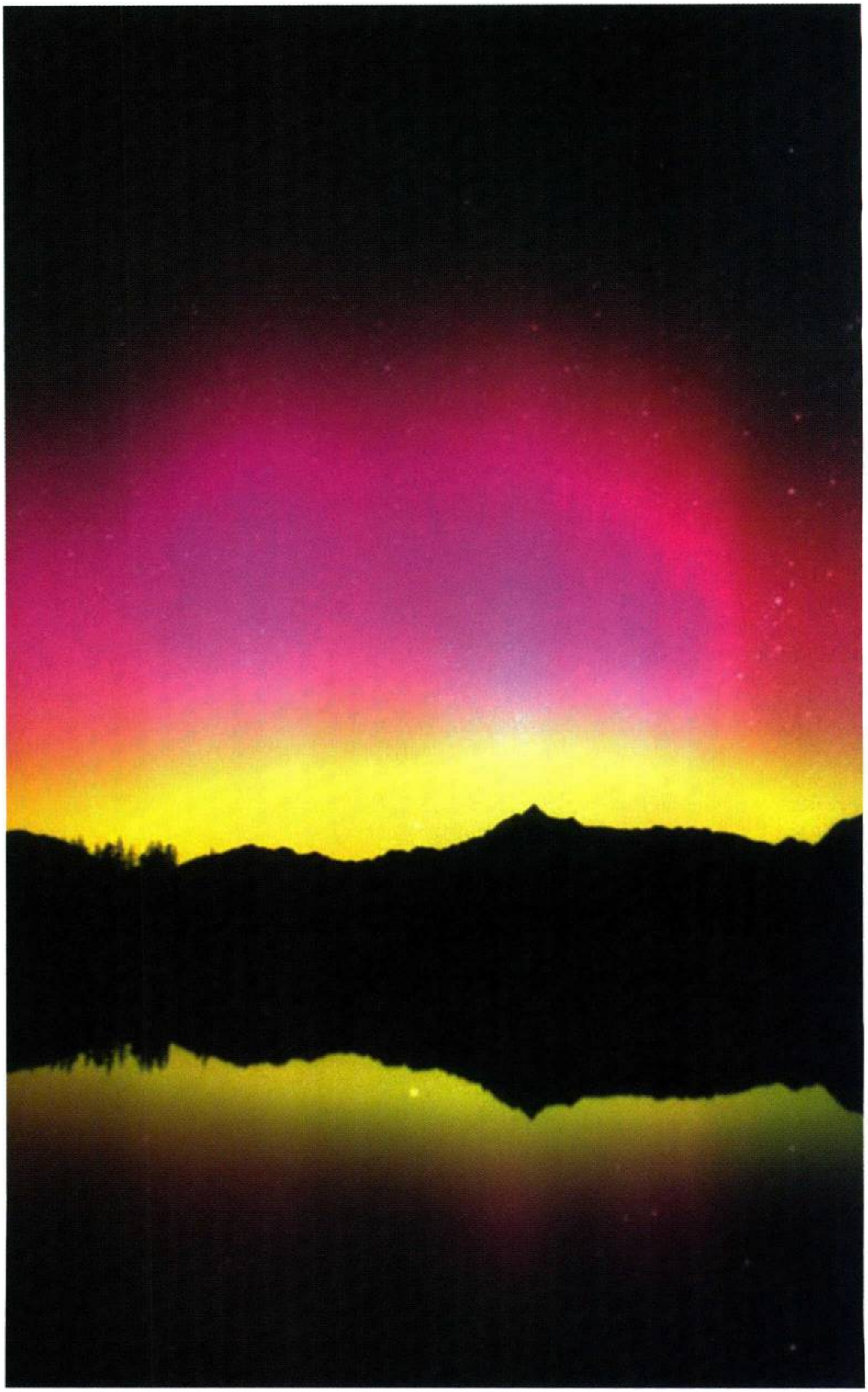
Meteors were all over the sky! The first bolide I saw was directly overhead. It was so bright that I closed my eyes out of reflex response. It left a train that was about 40° long, 5° wide, and lasted 20 to 30 minutes. Mike had never seen anything like it. That is until the next one.

I went into the house to get film for my camera. While I was inside, a brilliant flash came from the southwest, lighting up the interior of the house. I ran out, yelling, "What was that?" Mike was standing and pointing to where the train was still lingering. His second fireball.

We lost count of fireballs but estimated a rate of about 200 to 250 meteors an hour. The intensity was greatest between 1 and 3 A.M. that morning. After two hours we believed that the meteor storm was subsiding. It was a good time for a break.

We went back inside to get a bit more sleep but found ourselves outside again around 4:30 A.M. Meteors were still flying, but not as many as before. Mike said that if he had not seen the previous two hours' worth of fireballs, he would have been more impressed with the later display. We gave up at sunrise for that day.

That evening, Tuesday, November 17, there was an open house in Crane Observatory on the Washburn University campus. We had press coverage. We also had 250 to 300 people show up. Of course we could not see many meteors from downtown Topeka, but we did show Jupiter and Saturn through the telescopes. We



Northern Lights

WADE B. CLARK, JR.

(28mm lens at f/1.8, Fuji Superia 800 film, 60-second exposure taken July 11, 1999)

Leonid Bolides

ARANGO M. ADOLFO

(35mm lens at f/3.5, 400 ISO Fujichrome film, taken November 17, 1998)

Comet Lynn (C/1999 N2)

AL KELLY

(8-inch SCT at f/5.6, CB245 CCD camera, composite of 10-minute infrared, 7-minute cyan, 7-minute magenta, and 7-minute yellow exposures taken July 31, 1999)

also told people where and how to watch the Leonids. About half the people took off for darker skies. We closed at 9 P.M. when the crowds began to dwindle.

I went home to nap for the evening's viewing activities. I set the alarm again for 12:30 A.M. and awoke to a mostly cloudy, windy night with a clear pocket directly overhead. Through this window I could still see meteors, but weather conditions were just a bit too much for me. I went back in and got up a few hours later to a very cloudy day.

I am glad I went out on Monday night. Mike and I were definitely not disappointed in the much-touted Leonids show. He's ready for the next shower but doesn't expect to see anything like last year's Leonids for a long time. ◼

Brenda Culbertson is a researcher, educator, and freelance writer at Washburn University in Topeka, Kansas.

Clusters in Dorado (NGC 1929, 34 – 37, 55, 68, 74)

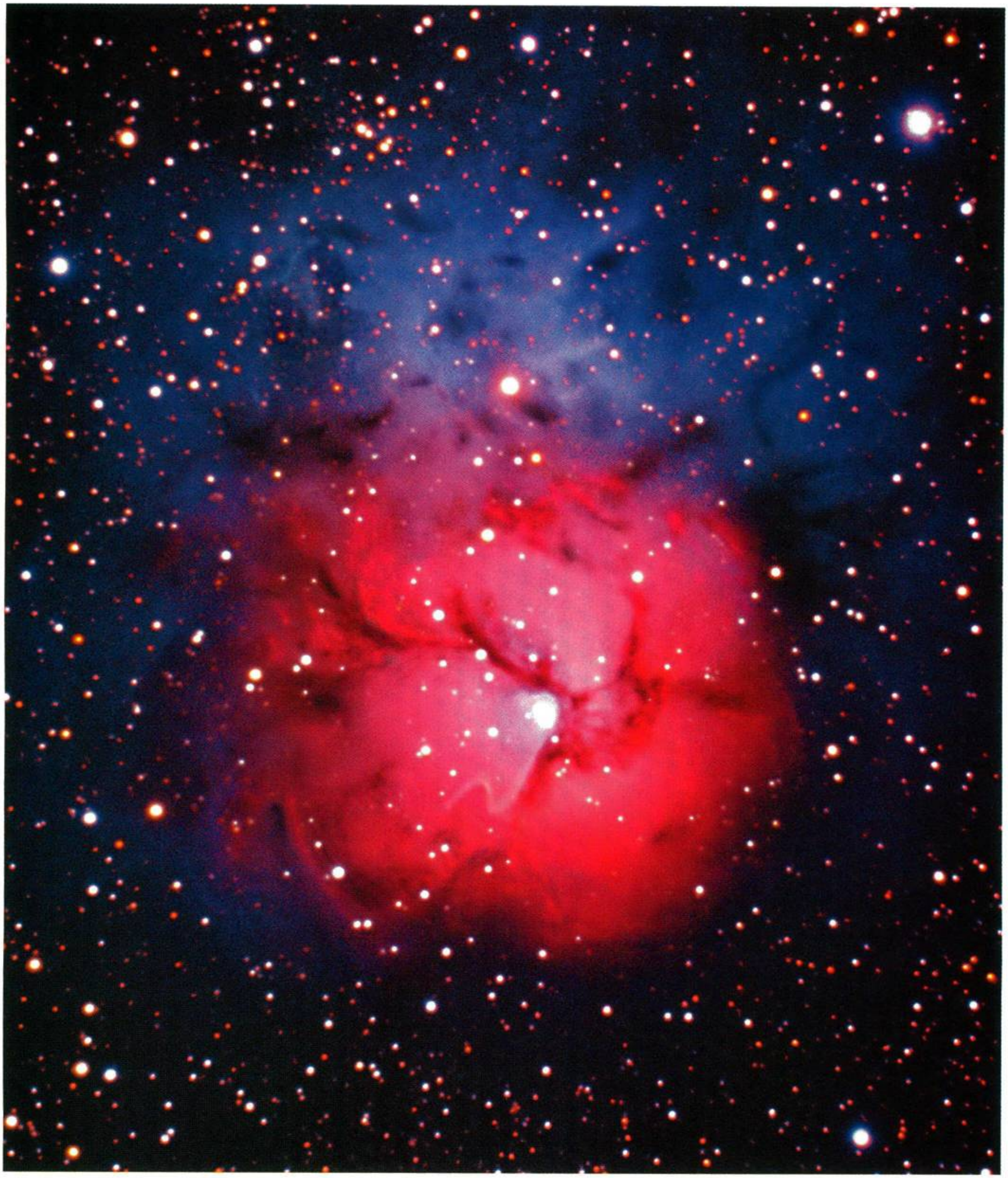
ANDREW PETERS

(20-inch f/5 reflector, Kodak Pro PPF 400 film, 60-minute exposure)

The Running-Man Nebula (NGC 1973-5-7)

BOB AND JANICE FERA

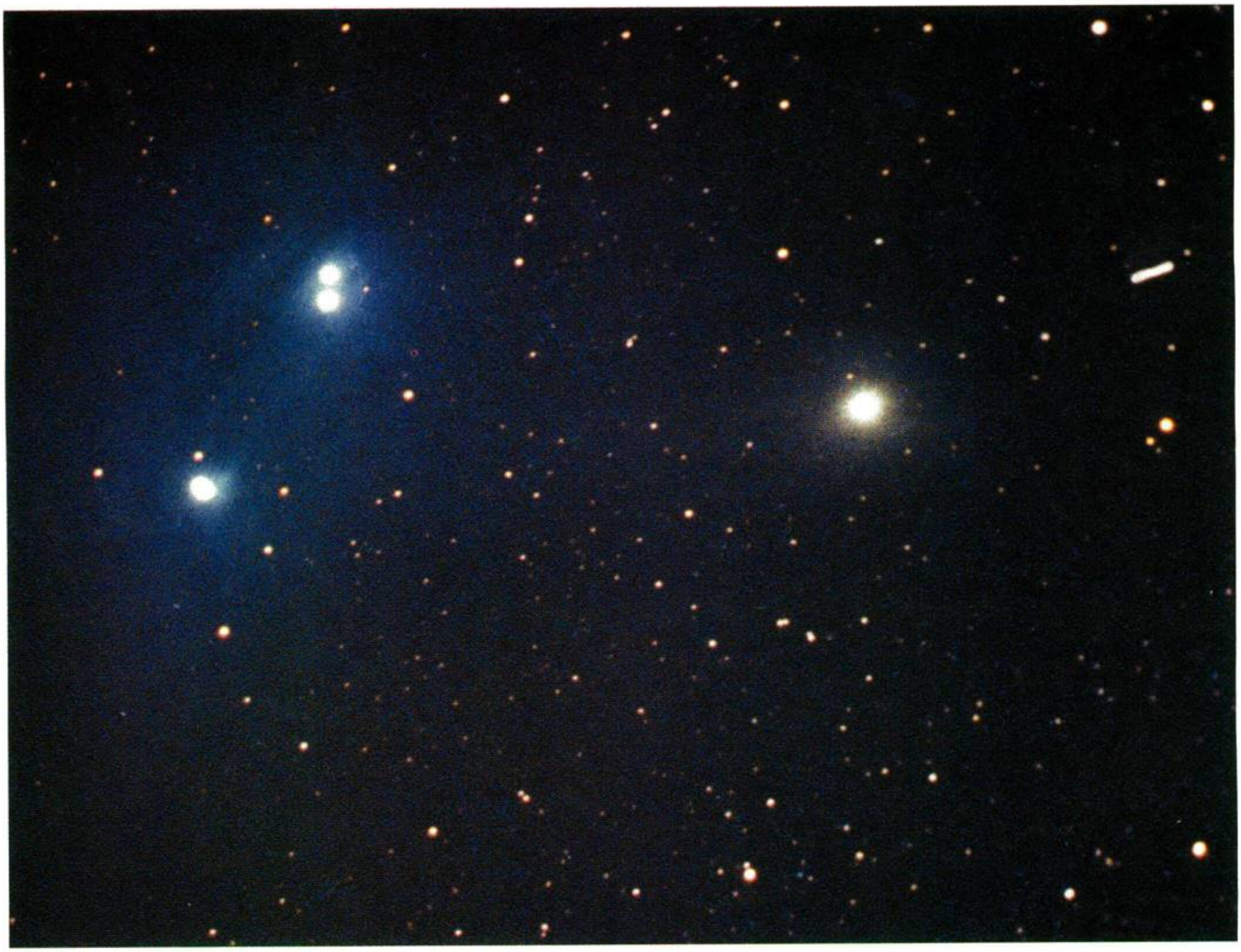
(11-inch SCT at f/10, hypered Kodak Pro PPF film, composite of three 60-minute exposures)

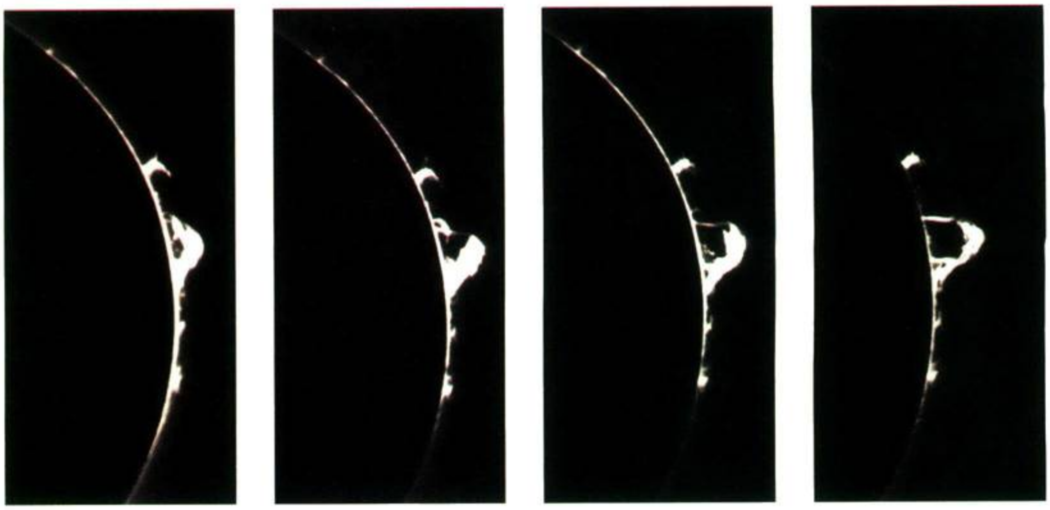


The Trifid Nebula (M20)

GEORGE GREANEY

(14-inch SCT at f/7, hypered Kodak PPF Pro 400 film, composite of three 45-minute exposures)





Thalia Visits the Scorpion

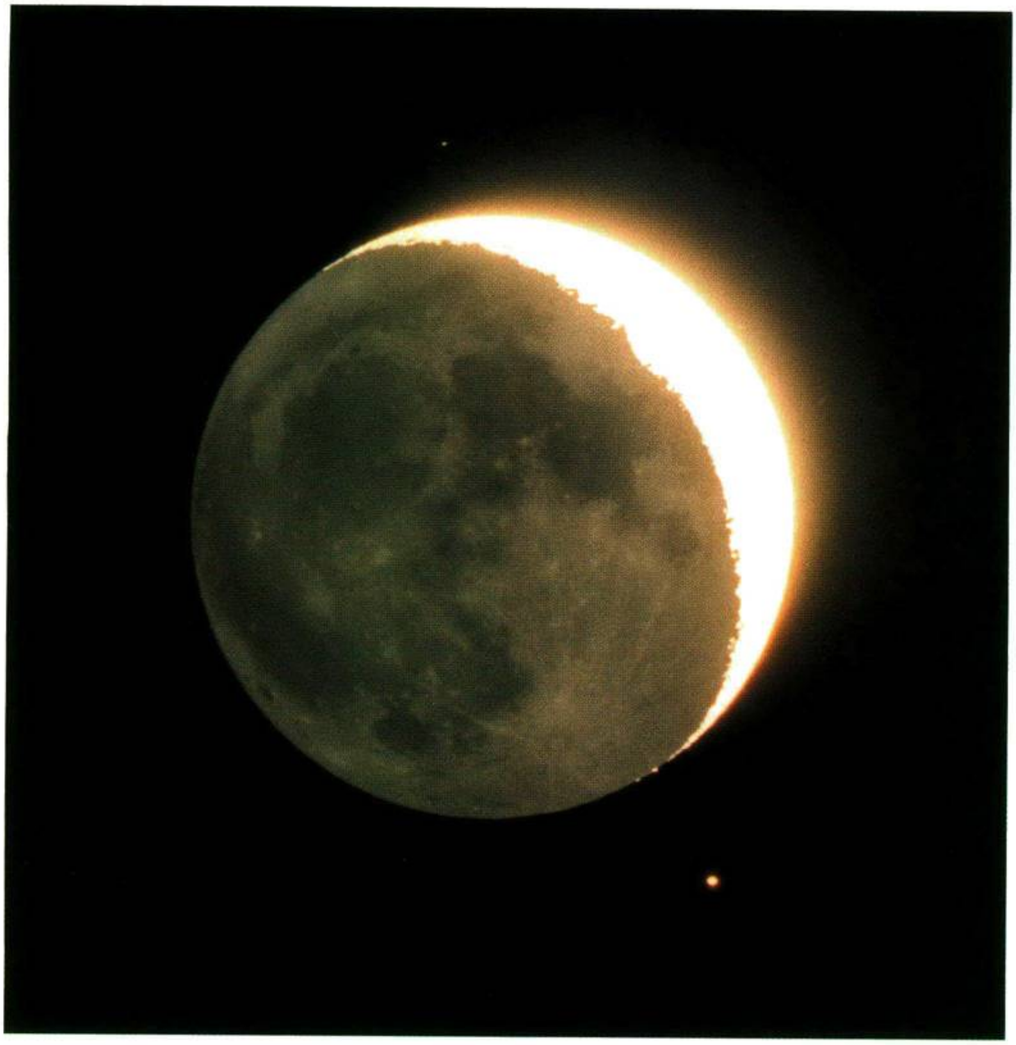
GERALD RHEMANN AND FRANZ KERSCHE

(11-inch SCT at f/7.0, composite of two 50-minute exposures taken May 18–19, 1999)

Life Cycle of a Coronal Loop

BARRY REYNOLDS

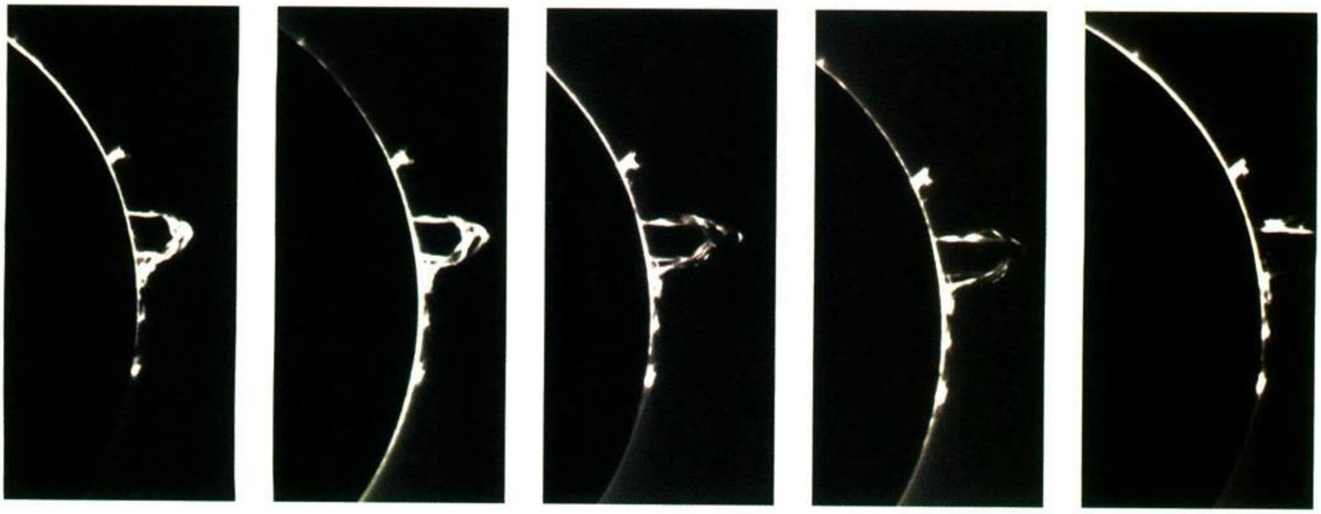
(90mm refractor at f/36.5, Tech Pan 2415 film, DayStar Hα filter and homemade coronagraph, ¼ to ½-second exposures taken June 16, 1999)



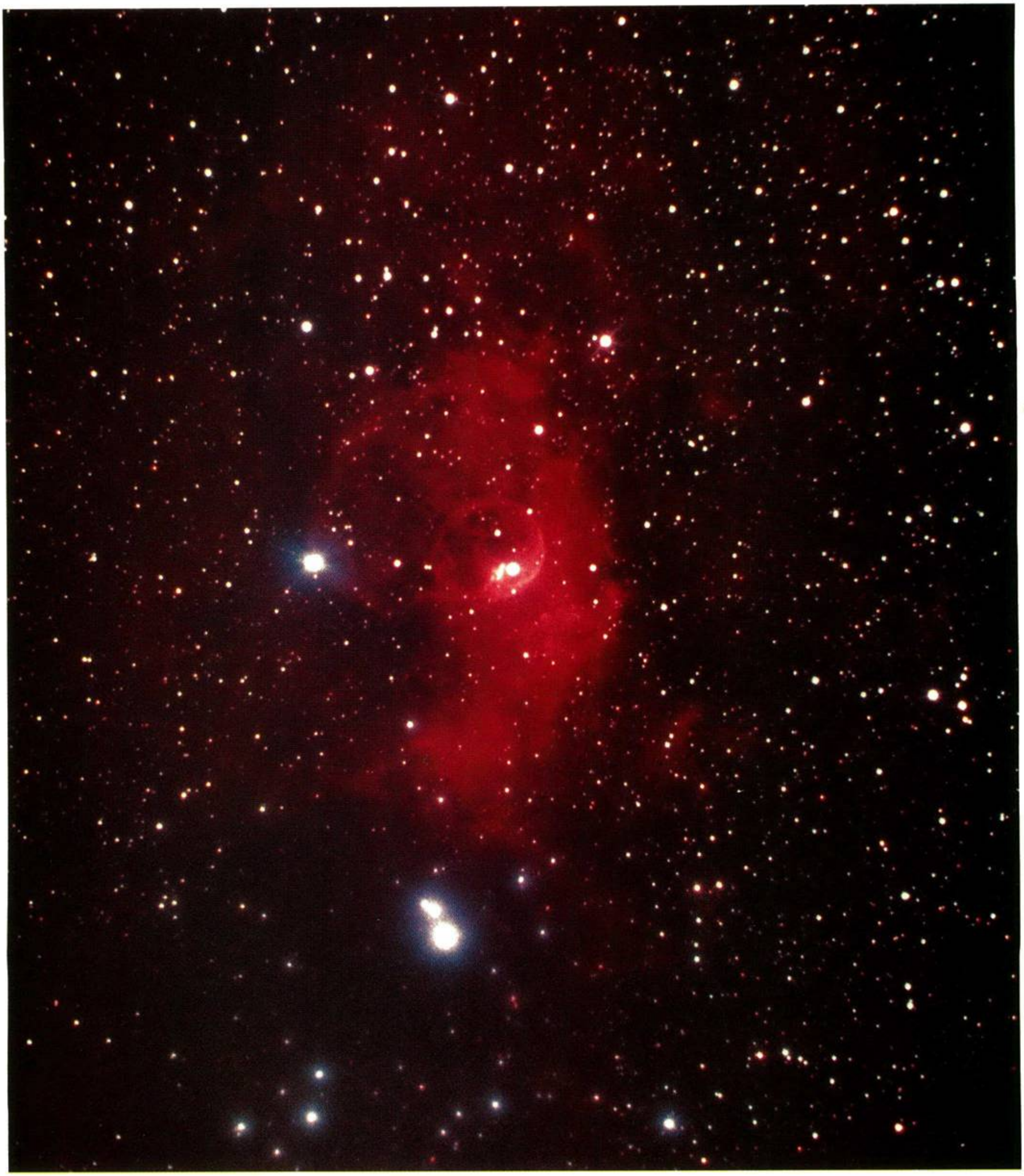
The Moon Dwarfs Aldebaran

ERIC AND DONNA SMITH

(8-inch SCT at f/6.3, ISO 400 film, 5-second exposure taken May 18, 1999)



This month's best astrophoto



The Bubble Nebula (NGC 7635)

KEN BLANKENSHIP AND DENNIS BATIS

(14-inch SCT at f/7.5 , hypered Kodak PJ-400 film, filtered 210-minute exposure)

A hot stellar wind from a 7th-magnitude star forms the Bubble Nebula (NGC7635) in Cassiopeia.

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Photo of Horsehead Nebula taken with Pronto by Ralph Sieger

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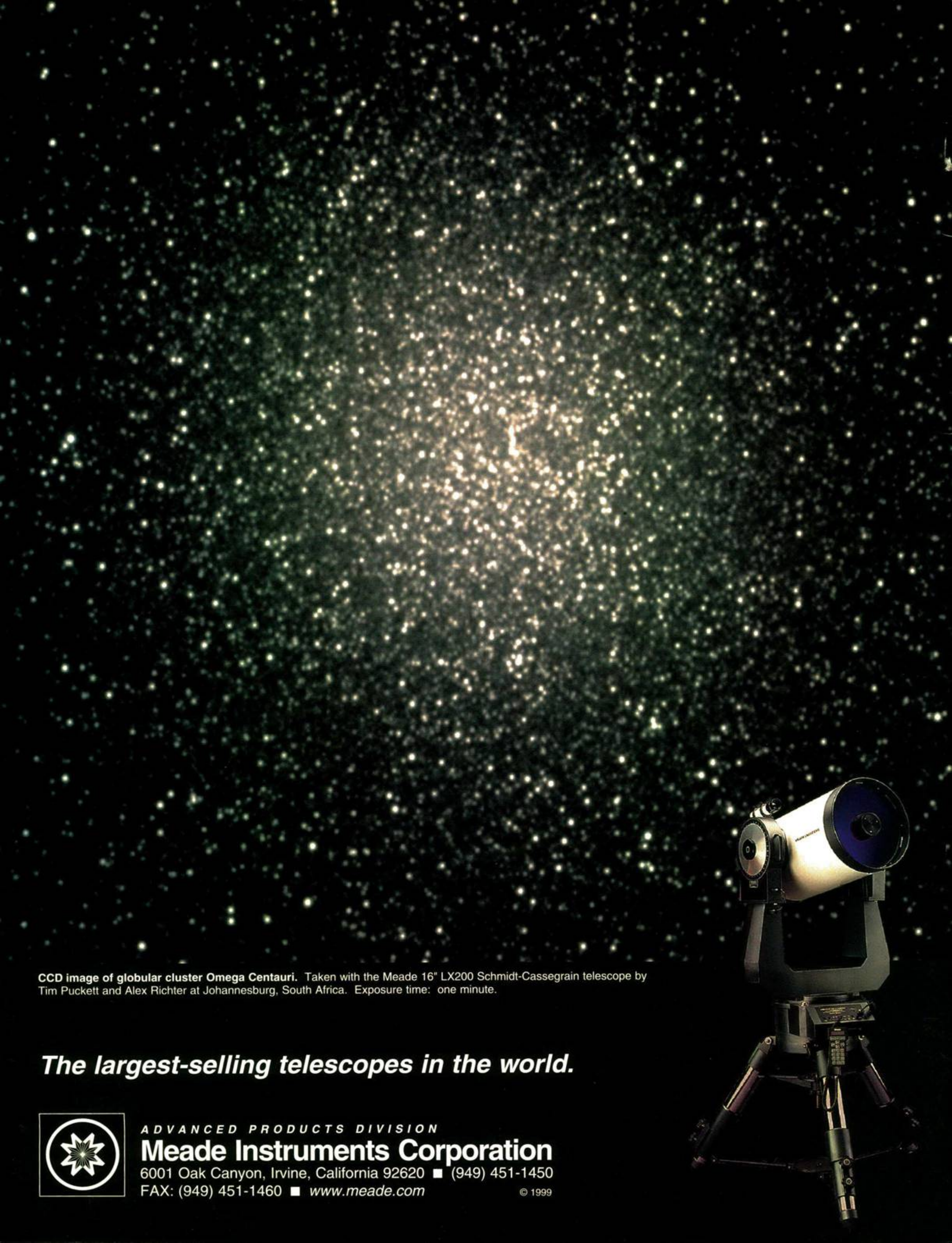

CCD image of globular cluster Omega Centauri. Taken with the Meade 16" LX200 Schmidt-Cassegrain telescope by Tim Puckett and Alex Richter at Johannesburg, South Africa. Exposure time: one minute.

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